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OLDMAN RIVER DAM ENVIRONMENTAL MITIGATION/OPPORTUNITIES PLAN

PHASE II
FISH DISTRIBUTION, ABUNDANCE, CRITICAL HABITATS AND RELATIONSHIPS WITH STREAMFLOW DOWNSTREAM OF THE OLDMAN RIVER DAMSITE

ENVIRONMENTAL MANAGEMENT ASSOCIATES

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PHASE II
FISH DISTRIBUTION, ABUNDANCE, CRITICAL HABITATS AND RELATIONSHIPS WITH STREAMFLOW DOWNSTREAM OF THE OLDMAN RIVER DAMSITE

Prepared for:

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JULY, 1986

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1.0 EXECUTIVE SUMMARY

The Government of Alberta has announced the construction of a dam on the Oldman River for the purpose of providing a dependable, multi-purpose water supply for this region of the Province. One of the primary water requirements downstream of the dam is the instream flow needs of the fishery resource in the river.

The present study involves two aspects of the data collection phase in regards to the fishery resource downstream of the damsite. The first component of the study relates to the existing fishery resource in this region of the river. Fisheries sampling was conducted in the Oldman River between the damsite and the confluence with the Little Bow River during the summer (7 July to 6 August; 26 August to 30 August) and fall (2 October to 23 October) of 1985. As a result of this sampling effort, the fish fauna of the study area was identified, and important fall spawning and nursery habitats were defined. Two macrohabitat types exist within the study area, an upstream coldwater and a downstream coolwater region of the river. The transition zone between the cold and coolwater habitats occurs between LNID and the Highway 2 Bridge.

Mountain whitefish and rainbow trout are the primary sport species using the coldwater habitat in the study area. Mountain whitefish used this habitat for spawning, rearing and summer feeding during the study period. Rainbow trout primarily used the coldwater habitat for rearing, although some adults were present in the summer, and adults appeared to move into this region during the fall, likely for overwintering.

The coolwater zone of the river was not heavily used by fishes during the study period, due to the low water levels in the river during the summer of 1985. The sport species recorded in this region of the river included mountain whitefish, walleye, sauger, mooneye and northern pike. Upstream access for fishes in the Oldman River is regulated by the weir at Lethbridge. As no fish passage facility exists at the weir, relatively high river stages are required to provide passage. It is not known if

fishes failed to ascend the river in the spring and early summer of 1985, or if they left the study area prior to July due to low water levels. The greatest utilization of the coolwater habitat was actually that of mountain whitefish, which is classified as a coldwater species but exhibits a very wide thermal tolerance.

The second component of the fisheries investigations downstream of the damsite in 1985 involved the collection of field data necessary to use the Instream Flow Incremental Methodology (IFIM), which provides information on the effects of river flow on fish habitat. Hydrologic and habitat measurements were made at two river stages (late June, early July), in one reach within each of the six river segments in the study area. The study was initially designed to provide measurements at three river stages, but fall precipitation resulted in very high rather than low river stages during the fall season, which precluded low river stage measurements.

The river stage information was used to build and calibrate the Water Surface Profile (WSP) model, which serves to predict river stage with a given flow. The calibrated WSP model was then merged with the IFG-4 model, which uses recorded velocity, substrate and cover distributions within the study reach and predicts the distribution of these characteristics at specified flows. These two programs, once calibrated, predict the distribution of these habitat characteristics in the river at a specified river discharge.

Data were also collected during the present study to describe the habitat characteristics preferred by mountain whitefish for spawning, as well as fry, juvenile and adult summer use areas. The habitat characteristics preferred by rainbow trout juveniles for rearing were also defined. Preferred habitats were identified by observing these fish in the river, and conducting measurements of habitat characteristics at the observation points. The resultant relationships were then corrected for habitat availability, with the ultimate product being a habitat preference curve by life stage.

The HABTAT model of PHABSIM was then employed to describe the habitat availability in each river segment for the species and life stages for which habitat preference curves were developed. The habitat availability was determined for the flows at which the hydrologic/habitat measurements were conducted in 1985. The model is presently stored at the University of Calgary computer facility, and will be used to assess the effects of various reservoir releases on the fishery resource during project planning.

2.0 INTRODUCTION

The Government of Alberta has announced its intention to construct a dam on the Oldman River for the purpose of providing a dependable, multi-purpose water supply, that would also permit substantial expansion of irrigation in southern Alberta. One of the primary water demands downstream of the reservoir is maintenance of suitable flows to provide adequate fish habitat.

The Planning Division of Alberta Environment retained Environmental Management Associates (EMA) to conduct a study of the existing fishery resource in the Oldman River between the proposed damsite and the confluence with the Little Bow River, and to provide quantitative information on the abundance and quality of fish habitat in this study area (Figure 1). The latter component of the study involves an instream flow needs (IFN) investigation.

Figure 1.
Location of Study Area.

3.0 OBJECTIVES AND TERMS OF REFERENCE

An initial overview report was prepared which compiled the existing fisheries information for the Oldman River between the headwaters and Fort MacLeod, as well as the lower reaches of the Castle and Crowsnest rivers (Allan 1985). In addition to summarizing existing information, specific deficiencies which precluded an assessment of the project and the development of suitable mitigation measures for potential negative impacts were identified in the data base. One of the data deficiencies involved a definition of the instream flow needs of the fish fauna between the proposed damsite and the Little Bow River confluence. To meet this data deficiency, the following objectives for the present study were developed:

1. Collect hydrological data in the Oldman River of suitable accuracy and format for use in the Instream Flow Incremental Methodology (IFIM) IFG-4 model as developed by the Instream Flow Services Group of the U.S. Fish and Wildlife Service.

2. Obtain data on the use of habitat by various life stages of sport fish so that suitability-of-use curves can be developed.

3. Use PHABSIM to analyze microhabitat conditions in the study area and provide preliminary recommendations of instream flow needs.

4. Gather data on seasonal distribution and abundance, and on critical habitats of sport fish from the Instream Flow Needs (IFN) study area. Provide a biological assessment of the response of sport fish to conditions encountered during the field study.

The initial study design involved fisheries investigations of the Oldman River during the spring, summer and fall of 1985, in conjunction with the necessary hydrologic and habitat measurements required to develop the data set for use of IFIM.

Initial difficulties with contract administration resulted in a modification of this study design. Two separate contracts were signed, the first of which involved collection of hydraulic/hydrologic data for use of IFIM. The specific Terms of Reference for this study follow:

1. Establish segment boundaries and select representative and critical reaches for each segment. Selection will be done in co-operation with Fish and Wildlife Division and Alberta Environment. A minimum of six segments will be required between the proposed dam site and the confluence of the Little Bow River with the Oldman River.

2. Locate study transects within each study reach so that:
   a) the hydraulic simulation of each reach can be carried out;
   b) the available fish habitat types in each reach can be defined.
   The number of transects required in each reach may vary depending on the hydraulic characteristics and habitat conditions in each segment. In general, transects should be selected to include one riffle - pool cycle.

3. Surveying will be done by professional surveyors using an AGA Geodimeter (accuracy $\pm$0.01 m). All cross-sections should be clearly identified in the field with permanent headpins placed above the high-water mark and tied into GSC bench marks.

4. Hydrology measurements will be taken at three discharges that encompass both average and low flows. Discharge measurements will meet Water Survey of Canada standards, namely: a minimum of 20 sections with a maximum of 10 percent flow in any one vertical. For depths less than 1 m, velocities will be taken at 0.6 depth; at depths greater than 1 m, velocities will be taken at 0.2 and 0.8 depth. During hydrology surveys, the senior fisheries biologist in charge of the program will be in the field in order to supervise the work.

These Terms of Reference were amended in early October to remove the requirement for hydrologic measurements at three discharges. Rain and snow storms during the fall resulted in river stages which approximated the spring flows measured in late June, and thus the anticipated low flows during the fall did not occur.

The second service agreement involved the collection of fisheries information within the study area. As the contract was not finalized until the summer season, the initial objectives of the ecological component of the study were modified to the following form:

1. Obtain data on the use of habitat by various life stages of sport fish so that suitability-of-use curves can be developed.

2. Use PHABSIM to analyze microhabitat conditions in the study area and provide preliminary recommendations of instream flow needs.

3. Gather data on seasonal distribution and abundance, and on critical habitats of sport fish from the IFN study area. Provide a biological assessment of the response of sport fish to conditions encountered during the field study.

The specific Terms of Reference for this service agreement follow:

Species Criteria Curve Development

1. Habitat utilization will be documented by direct observation wherever possible (either direct observation from the banks or by using floating techniques for underwater observation). Electroshocking and/or seining will only be used if special conditions preclude direct observation. Special care will have to be taken if electrofishing or seining is used to determine if the actual preference areas are being documented with sufficient reliability to establish utilization curves.

2. Curves will be developed for fry, juvenile and adult sport-fish species. Emphasis will be placed on those species and life stages that are relatively abundant in the various segments. Both coldwater and coolwater species will have to be considered since the study area includes a transition zone between coldwater and coolwater species (Radford 1975; Allan 1985). A minimum of 100 data points will be collected for the suitability criteria for summer habitat use by mountain whitefish fry, juveniles and adults, and rainbow trout juveniles. One hundred data points will also be collected for spawning mountain whitefish.

   Attempts will be made to collect suitability data for all life stages of walleye, sauger, lake whitefish and goldeye and for adult rainbow trout if adequate numbers of these species and life stages are available within the study reaches selected for this study.

WUA Curve Development

1. Prepare the complete field hydraulic data set for use in PHABSIM for analysis of microhabitat conditions within the study area. The consultant will be provided with access to Alberta Environment's PHABSIM program at the University of Alberta computer facility or an alternate commercial facility. Ensure that the data is correctly input and balanced so that test runs can be undertaken.

2. Using the utilization data collected during the field program and model estimates of the available habitat, prepare preference curves for the species and life stages studied.

3. Use the PHABSIM model to obtain the weighted usable area (WUA) for each representative or critical reach, each life stage and species, and each flow occurring in the reach. Initial runs will be used to establish microhabitat

conditions under normal flow conditions for the Oldman River and to provide preliminary recommendations of instream flow needs.

Population Dynamics and Critical Habitat

Gather data on the fish species composition, seasonal distribution and abundance, and on critical areas such as spawning, incubation and rearing locations at study sites established in the various IFN segments on the Oldman River. Obtain sufficient data that preliminary mitigation concepts or strategies can be developed for altered flow regimes such as lower or higher flows, reduced 'flushing' flows and increased seasonal flow consistency and for seasonal water temperature changes that result in the loss of ice cover or increased anchor ice formation. Provide recommendations on minimal and optimal water quality conditions (primarily temperature and oxygen) required for important fish species downstream of the dam. Compare your recommendations to predicted reservoir outflow water quality and identify discrepancies.

Due to the late date at which the contract was awarded for the ecological component of the investigation, no investigations could be conducted during the spring spawning period in the study area.

4.0 METHODS

The following section of the report is divided into two components: investigations involving the IFIM aspect of the study; and, methods employed in the study of population dynamics and critical habitats of the fish fauna in the study area.

4.1 INSTREAM FLOW INCREMENTAL METHODOLOGY TECHNIQUES

4.1.1 Hydrology and Habitat Measurements

The purpose of this component of the study was to collect the information necessary to define the existing characteristics of the Oldman River between the damsite and the Little Bow River confluence. To facilitate this aspect of the investigation, 1:250 000 and 1:50 000 scale National Topographic Series (NTS) maps were examined for homogeneity of the Oldman River channel structure, and Water Survey of Canada (WSC) records were reviewed to identify inflows and outflows from the river which would alter the flow regime by more than 10 percent (Bovee 1982). On the basis of this evaluation, six river segments were identified in the study area. Segment boundaries, segment lengths and segment characteristics are presented in Table 1. The river was flown on April 3, 1985 by fixed-wing aircraft (Cessna C-180) to confirm both segment boundaries and homogeneity within river segments.

During the process of segment identification, one of the criteria employed was the consideration of critical reaches in the study area. A critical reach is defined as a portion of the river containing a particular microhabitat type that is absolutely essential for the completion of one or more life stages of a species and is absent or in short supply in areas of the river chosen for detailed study (Bovee 1982). Critical reaches may involve spawning, incubation, nursery areas (regions used by young-of-the-year) or migration routes. In the case of migration routes, fish passage must be considered. If a barrier to fish movement exists at all flows in the river, this point becomes a segment boundary. Within the study area,

TABLE 1

SEGMENT BOUNDARIES AND LENGTHS IN THE OLDMAN RIVER STUDY AREA

River Segment	Segment Boundaries		Segment Length (km)	Segment Characteristics
	Downstream	Upstream		
1	Little Bow River	St. Mary River	69.5	Deeply incised, relatively narrow valley, minimal meandering. St. Mary River inflow at upper segment boundary.
2	St. Mary River	Belly River	31.5	Deeply incised valley, wide floodplain, moderate meandering, Belly River inflow at upper segment boundary.
3	Belly River	Rocky Coulee	24.2	Relatively narrow valley , minimal meandering.
4	Rocky Coulee	LNID Headworks	55.3	Wide valley and unstable gravel floodplain, moderate meandering, LNID withdrawal at upper segment boundary.
5	LNID Headworks	2 km upstream of Highway 785 (Summerview) Bridge	32.6	Wide valley and unstable gravel floodplain, moderate meandering.
6	2 km upstream of Highway 785 (Summerview) Bridge	Damsite		Narrow valley, unstable gravel floodplain, minimal meandering.
Total			218.5	

two impediments to fish movment exist. These are the weir at Lethbridge, and the water control structure at the Lethbridge Northern Irrigation District (LNID) headworks. Fish movements over the Lethbridge Weir are possible during periods of high flows, whereas a vertical slot fishway operated at the LNID weir permits fish passage throughout the year. These two locations were therefore identified as critical reaches, as opposed to segment boundaries. A further discussion of critical reaches is presented later in this section of the report.

Within each of the six river segments, individual study areas (called reaches in IFIM terminology) were identified for detailed field measurements. Due to the homogeneity of the river within segments, it was determined that detailed examination of one reach would suffice to describe the habitat availability in each river segment. A series of candidate reaches (varying from four to seven) was identified for study within each segment. Candidate reaches were selected from an examination of 1:50 000 scale NTS maps, and both 1:60 000 (1981 photography) and 1:36 000 (1961 photography) scale air photographs. Representative reaches were selected on the basis that virtually all characteristics of the segment which the reach may represent were present in the reach.

Final selection of the single study reach for each segment was conducted on May 1, 1985. The identification of each study site from the candidate reaches was carried out during a helicopter (Bell 206B) reconnaissance of the study area. The team involved in final reach selection consisted of personnel from the Planning Division (Bill Griffiths) and Technical Services (Elliot Kerr) of Alberta Environment, the Fish and Wildlife Division (Frank Bishop), and the senior author. During final reach selection, each candidate reach in a river segment was evaluated, and the preferred reach identified. Each selected reach was then walked from one end to the other, and tentative study transects established and temporarily marked by the team members. The locations of representative reaches employed in the investigation are illustrated on Figure 2.

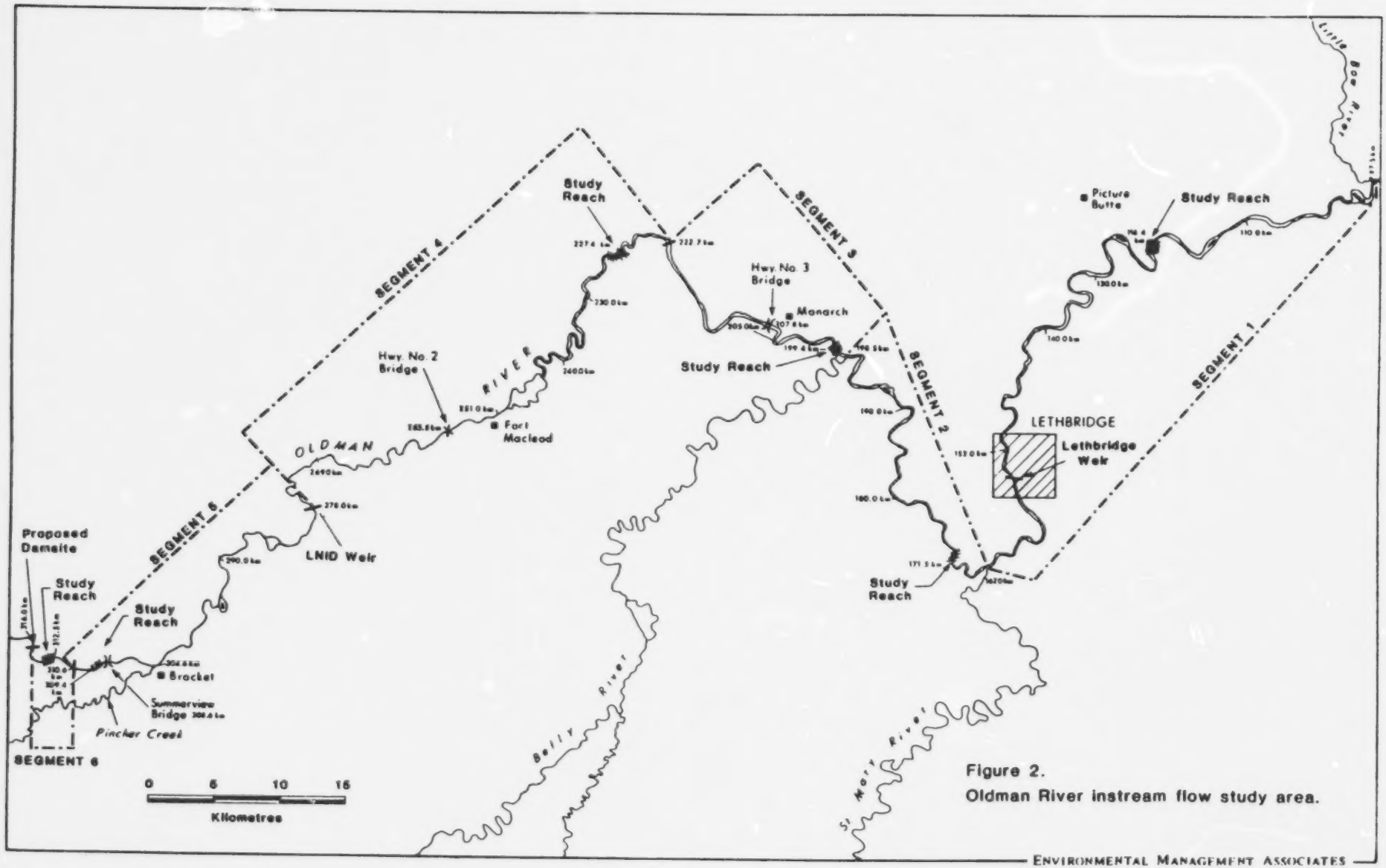

Figure 2.
Oldman River instream flow study area.

The second type of microhabitat study area considered in the investigation was critical reaches. As previously described, these reaches include habitat considered critical to one or more life-history stages of the fish fauna. In terms of reproductive activities, the only spawning/egg incubation information that existed for the important fauna in the study area was the location of mountain whitefish spawning areas. (The common and scientific names of all fishes discussed in this report are presented in Appendix I). The extent and degree of use of mountain whitefish spawning areas between the damsite and LNID were described as a result of previous investigations on the river (O'Neil et al. 1982). Candidate reaches in Segment 5 were chosen in an area defined as a high use mountain whitefish spawning area in 1982; all of Segment 6 in the study area was identified as a moderate to high use spawning area for this species.

Therefore, no critical reaches were identified for the study on the basis of known, unique and essential microhabitats for the fauna. Two critical reaches were established on the basis of fish passage requirements, however. As previously described, these included the LNID Headworks and the Lethbridge Weir. Three critical reaches were initially identified, on the basis of a literature review. Longmore and Stenton (1981) reported the existence of a weir at Fort MacLeod which precluded fish movement in the river. During the aerial surveys of the river it was determined that such a weir no longer existed. This blockage may have been a gravel berm which was used at one time to facilitate water removal for the City of Fort Macleod.

Transect locations within each reach were finalized between May 27 and May 29, 1985. Unfortunately, both reach selection and transect location identification were conducted at higher river stages than desirable. This situation resulted from administrative difficulties in securing contract approval. Transects were established at all hydraulic controls apparent in the study reach at that time, as well as through representative habitat types. The boundaries of each study reach were established on hydraulic controls. Each reach consisted of at least one pool/riffle cycle. Reach lengths varied from approximately 500 m to 1 000 m, while the number of transects established per reach ranged from five to eight. These data are summarized in Table 2.

TABLE 2

SHORELINE LENGTHS AND NUMBER OF TRANSECTS IN REPRESENTATIVE REACHES, OLDMAN RIVER, 1985

Reach	Shoreline Length between Headpins(m)[a]		Number of Transects
	LHS	RHS	
1	993.81	887.71	7
2	995.66	815.11	7
3	601.96	803.61	5
4	939.92	941.26	8
5	496.16	540.59	6
6	437.84	577.39	7

[a] LHS = left-hand side looking downstream
RHS = right-hand side looking downstream

Transects were identified by installing headpins (0.6-m lengths of 12-mm diameter rebar) at the extremity of each transect. Headpins were generally located above the high-water mark, at the edge of the permanent riparian vegetation. Workpins were installed near the water's edge on transects where headpin elevations were too high to enable use of a tagline and boat for measurements without significant sag in the tagline. Geodetic headpin and workpin elevations were determined by the McElhaney Group Ltd. of Calgary, Alberta, between 7 and 16 October, 1985.

Transects were not established at the two critical reaches in the study area, for the following reasons. The requirement for fish passage at the Lethbridge Weir entails an increase in river stage downstream of the weir to the point where the water surface elevation exceeds the weir elevation. The modeling involved for such a determination is difficult, and the field measurements required even more difficult due to the hydraulic characteristics of the weir. Alternative sources of information were pursued for this analysis, which included a determination of the weir elevation, a determination of the gauge elevation at the Water Survey of Canada Station (05AD007) located 3.3 km downstream of the weir, and a determination of river slope (difference in water surface elevation) between the spillpool of the weir and downstream gauge. These measurements were made on 16 October, 1985, with the use of automatic level (Nikon AE-5) and rod, using benchmarks established at the pumphouse in the City of Lethbridge and at the Water Survey of Canada stream gauge.

The vertical slot fishway operated at the LNID weir is not operated as a run-of-the-river fishway, but may be operated to meet flow requirements through the structure. As such, no modeling of the characteristics of the fishway is required to determine the effects of flow alteration in the Oldman River.

The study design established for the Oldman River IFN investigation involved detailed measurements of the river at three stages on the declining hydrograph (i.e., subsequent to peak flows during the freshet).

It was proposed that measurements would be conducted at a reasonably high stage in late June or early July, as soon after freshet as work could be conducted on the river (in excess of 50 m^3/s), at a moderate flow (approximately 15 m^3/s) in late July or early August, and a low flow (in the range of 5 m^3/s) in late September or early October. The latter two study periods were identified to coincide with the collection of fisheries information for the study, to develop the best data base possible for subsequent analyses.

Unfortunately, the river stages which occurred in the Oldman River during the open-water seasons of 1985 precluded such a study. The initial hydrology field program commenced on 19 June, at Segment 1. The Oldman River was discharging at approximately 65 m^3/s at Lethbridge and 56 m^3/s at Brocket at that time. The high flow measurements were completed at Segment 6 on 28 June, at which time river flow at Brocket was approximately 34 m^3/s, and 19 m^3/s at Lethbridge. Due to this dramatic decrease in the hydrograph, the second set of hydrology measurements commenced almost immediately. The second data collection trip began on 3 July, at which time flows at Lethbridge were approximately 12 m^3/s, while those at Brocket were approximately 29 m^3/s. The second run was completed on 10 July, when flows at Brocket and Lethbridge were approximately 20 and 5 m^3/s, respectively. Flow in the Oldman River remained in this range through the summer season, until early September.

Precipitation during the fall resulted in a dramatic increase in river stage. Flows at Brocket increased from a minimum of 8.5 m^3/s on 1 September to 103 m^3/s on 13 September; on 30 September, river discharge at Brocket was still in the range of 35 m^3/s. Therefore, the flows experienced in the fall overlapped with those at which hydrologic measurements were conducted during the previous two surveys. Due to this fact, the requirement for measurements during a third river stage was removed from the Terms of Reference for the study.

The techniques employed during the collection of hydrologic and habitat information at study transects followed the specifications for use

of the IFG-4 hydraulic model. However, it has been determined that the IFG-4 model is generally ineffective in simulating river stages (K. Bovee, pers. comm.). River stage simulation in the present study was therefore conducted using the WSP program. The difference in data collection techniques for the two models is that a large number (minimum of four) of river stage measurements are required for the IFG-4 model, during which depth/velocity determinations are required at identical stations on each transect during measurement of the river stages. Use of the WSP program does not require multiple stage measurements on the river; measurements should, however, be conducted in the range(s) of the required simulation(s). Additionally, measurement stations on transects do not have to be identical with the WSP program if more than one river stage is examined. In the present program, the WSP and IFG-4 models were merged, with the WSP program predicting water surface elevations, and the IFG-4 model predicting velocity distributions across transects. The IFG-4 model is superior to WSP in this context.

The data collected for hydraulic/habitat simulation of the Oldman River included the following. At each transect across study reaches, a minimum of 20 stations were established within the wetted perimeter of the river on the first sampling trip; the mean number of stations on most transects exceeded 25. Ideally, stations are established at each elevation change in bottom profile of the river, or where substrate or river characteristics change. As the river profile and substrate/cover characteristics were observed to be relatively uniform, and excessive depths and turbid waters precluded observation of the river substrate during late June, stations on cross-sections were generally established at equidistant intervals across the transect. Where changes in profile or habitat characteristics were apparent, appropriate stations were established to describe these features. During the June and July sampling trips, measurements at stations involved water depth and a determination of mean column velocity. Depth was measured with a graduated wading rod (depth less than 1 m) or a sounding reel cable suspension system. The latter apparatus was mounted on a 3.8-m inflatable boat (Zodiac) powered by a 40 HP jet-driven Mercury outboard motor or 25 HP propeller-driven Mercury outboard motor.

Stationing across transects was determined with the use of a 9.5-mm diameter (June) or 3.2-mm diameter (July, October) steel tagline. Anchors were established on each side of the river at each transect; the tagline was attached to the anchors and tightened to remove sag with two come-alongs (winches). The taglines employed were marked at one-foot intervals. Water velocity was measured using Water Survey of Canada standards, which include measurements at 0.6 depth where depth was less than 0.75 m, and at 0.2 and 0.8 depth where depths exceeded 0.75 m (Terzi 1981). Velocity measurements during the hydrology components of the study were conducted with Price Type AA current meters; the wading rods employed were top-setting, while the reel cable suspension system used a 22.7-kg weight suspended below the Price meter.

Two staff gauges were installed during measurements on each study reach. One staff gauge was installed and maintained for the duration of measurements at each river stage, to identify any changes in river stage while measurements on all transects were conducted. A second, temporary gauge was installed and read at the beginning and end of measurements on each transect, to identify any changes in stage during measurements on each transect. Water surface elevations, in relation to headpin elevations, were determined for each side of the river while conducting measurements on each transect. Where measurements at a reach could not be completed in one day, water surface elevations on both shores at all transects were determined on each subsequent day at each reach. Wetted perimeter distances between transects on each shoreline were measured with a 100-m tape. In general, hydrologic measurements at each study reach required approximately 1.5 days (maximum - 3.0 days; minimum - 1.0 day). Measurements during June were conducted with a three- or four-person crew; July determinations were carried out by a two-person crew with the occasional assistance of an additional two-person crew.

Information requirements for habitat simulation modeling include determinations of substrate and cover characteristics at each measurement point. These characteristics do not change with river stage. When using identical stationing for measurements the determinations must be made only

once. The design developed by EMA for the study involved collection of this information at the lowest river stage measured, as determination of substrate and cover characteristics would be most accurate under these conditions. The study design therefore identified the late fall sampling period as being optimal for these observations; additionally, profiles from the high-water mark to headpins were to be determined at this time. As previously described, low-flow conditions did not occur during the fall of 1985; however, stationing on each transect was established through the use of taglines, and substrate and cover characteristics were determined at each station between 7 October and 16 October, 1985. The substrate and cover classifications employed are summarized on Table 3. Streambank profiles between headpins and the water's edge (as recorded during the June sampling trip) were determined with an automatic level (Nikon AE-5) and rod during this sampling period. River bottom profiles were determined from the difference between water surface elevations and the depth at stations as determined by wading rod or sounding measurements.

All data collected during the hydrologic/habitat measurement component of the study were recorded in field books or field forms, and were subsequently transposed to computer data sheets prior to leaving each study reach. The latter procedure was followed to ensure all necessary information was collected before departing from the study site.

4.1.2 Habitat Preference Information

The suitability of habitat for use by particular species and life stages of those species must be determined to facilitate the development of quantitative estimates of available habitat at different river stages. Although some suitability-of-use curves were developed and circulated early in the development of the IFIM technique (e.g., Bovee 1978), the majority (if not all) of these types of curves did not compensate for habitat availability when preferences were identified. A suitability-of-use curve which is corrected for habitat availability is termed a habitat preference curve.

TABLE 3

SUBSTRATE AND COVER CLASSIFICATION CRITERIA

Substrate

Recorded as percent composition for the entire cell that falls into the following categories

Category	Code	Size range (mm)
detritus	0	-
clay/silt	1	<0.062
sand	2	0.062-2.0
small gravel	3	2.0-8.0
medium gravel	4	8.0-32.0
large gravel	5	32.0-64.0
small cobble	6	64.0-128.0
large cobble	7	128.0-256.0
small boulder	8	256.0-762.0
large boulder	9	>762.0
bedrock	10	-

Cover

Recorded as percent of cell area with each cover type, recorded separately for rainbow trout fry, juveniles, adults and mountain whitefish fry, juveniles, adults

Category	Cover type
SB	substrate cover (e.g., cobbles, boulders)
LB	log and branch debris
LJ	log jam
RW	root wad
UB	undercut bank
OV	overhanging bank vegetation
AG	attached algae
VF	floating vascular plants
VS	submerged vascular plants
VE	emergent vascular plants
BW	backwater

Information available at the initiation of the IFN study on the Oldman River indicated significant use of the river by coldwater species between the damsite and the Little Bow River confluence was likely limited to rearing by rainbow trout (i.e., use by juveniles other than young-of-the-year), and all life stages of mountain whitefish. Therefore, data were collected to develop habitat preference curves for rainbow trout rearing, and mountain whitefish spawning, nursery (use by fry), rearing and summer feeding (use by adults). Although overwintering use by these species (and others) almost certainly occurs within the study area, use of this habitat occurred after the termination of the present study.

Use of the study area by other important coldwater (e.g., cutthroat trout, brown trout, bull trout) and coolwater (e.g., lake whitefish, walleye, sauger, goldeye, northern pike, lake sturgeon) species was known in general, but the extent of spawning, nursery, rearing, migratory or overwintering use was uncertain. These data gaps were to be filled during the population dynamics and critical habitat components of the present study, and the appropriate data collected if possible to prepare habitat preference curves for the life stages of these species. This component of the program (see below) was hindered by late study start-up, and very low water levels during the summer of 1985.

Several methods are available for developing habitat preference curves for the various life stages of the fishes under investigation. The method originally proposed for the present study involved conducting the hydrologic (i.e., habitat availability) and fisheries data collection components simultaneously. This technique enables the use of habitat availability data which is based on actual measurements, rather than simulated conditions as determined from running the Physical Habitat Simulation System (PHABSIM) programs. That is, although use of the PHABSIM technique is widely accepted, preference was given to actual rather than simulated conditions for determining habitat availability. However, due to the late start-up of the fisheries component of the study (i.e., mid-way through the second set of hydrology measurements), and the fact that habitat measurements were not conducted in October due to the high river stage, the measure of available habitat for use in the development of habitat preference curves was developed using the HABTAT model from PHABSIM.

The preferred technique for collection of habitat preference information is direct observation of fishes in their natural habitat. Use of the various fisheries sampling techniques typically employed (e.g, gill netting, seining, electrofishing) generally does not provide the necessary information for curve development, as it is difficult if not impossible to determine the actual microhabitat used by the fish prior to capture. It is also difficult if not impossible to determine the activity of the fish prior to capture (e.g., holding, feeding, spawning). Therefore, although the classic collection techniques (i.e., electrofishing, seining, gill netting) were employed in this study, and these data were maintained in a manner suitable for use in developing habitat preference information, data used to generate the habitat preference curves were generated from floating the river with wet or dry suit and snorkel, or from shore observation.

During the observation process, fish were identified to species, the fork length and location in the water column (i.e., distance from substrate) were estimated, and a marker (numbered buoy attached to an anchor) was dropped at the location where the fish was observed. The above-described information was recorded first on a divers slate, and then transposed to a field record book. Subsequently, measurements of depth, mean column velocity, nose velocity (i.e., velocity at the point in the water column where the fish was observed), substrate composition, and type and distance from cover were made. These characteristics were attributed to the species and life stage (as determined from length estimation and the results of age/length analyses described below) identified by the marker. Depth, velocity, substrate and cover determinations were conducted as described in Section 4.1.1, with the exception that a Marsh-McBirney Model 201B Electromagnetic Water Current Meter was used in addition to the Price meters for determining water velocities.

Efforts were unsuccessful in observing mountain whitefish spawning behavior, although observations were made during all daylight hours from dawn to dark. Habitat measurements for development of preference curves for spawning were conducted at locations where fertilized eggs were

recovered by kick sampling in the substrate, and where spawners were present in close proximity as determined by diver observation or electrofishing. If no adults were present in close proximity to egg recovery locations, the data collected at these egg recovery sites were categorized as egg incubation data. The rationale for this categorization was that because mountain whitefish are broadcast spawners, the fertilized eggs are subject to drift. If spawners were present at egg recovery locations, these locations were therefore assumed to be spawning locations. However, if spawners were not present, this assumption could not be made and therefore data were attributed to egg incubation locations. Very few data points were collected at egg incubation locations, as the field effort terminated at the end of mountain whitefish spawning behaviour.

In excess of 100 habitat measurements were made for each of the following life history stages: mountain whitefish spawning, nursery, rearing and summer feeding, as well as rainbow trout rearing. The technique employed to develop the habitat preference curves was a frequency analysis of characteristics at observation locations. These data were organized into histograms, which were subsequently divided by histograms which represented the available range of each habitat parameter following the technique described by Fernet and Walder (1986). The resultant relationship provides a true habitat preference curve, as the potential effects of habitat availability on habitat use are accounted for in the relationship.

This phase of the study was conducted by a two or three-person crew, between 7 July and 6 August, 26 August and 30 August, and 2 October and 23 October, 1985. All data were transposed in the field to appropriate computer data sheets for subsequent analysis. The habitat characteristics at observation locations have been summarized in Appendix II.

4.1.3 Calculations of Weighted Usable Area

The basis for evaluating the effects of an altered flow regime in

IFIM is to compare the relative amounts of usable microhabitat for species and life stages of concern at the various flow rates under consideration. The term applied to the amount of microhabitat available to a particular life stage is weighted usable area (WUA). The WUA is a discrete value for each representative reach, each life stage and species, and each flow occurring in the reach.

To calculate the WUA for the mountain whitefish and rainbow trout life stages under study, the calibrated WSP data deck was used to provide predicted water surface elevations at the measured flows in June and July. These predicted water surface elevations were entered into the IFG-4 model, which simulated water velocities across the transects and these two flows. The output from this program, as well as the habitat preference curves were then entered into the HABTAT program. One of the outputs of HABTAT is a listing of WUA for life stages specified by the preference curves and the specified discharge rate. To calculate the WUA for the river segment for which the reach was representative, the WUA per kilometre for the reach was calculated, which was then multiplied by the length of the segment in kilometres.

4.2 EXISTING FISHERIES RESOURCE

Fisheries inventory studies of the Oldman River were conducted by a two-person crew during the summer (7 July to 6 August and 26 August to 30 August) and fall (2 October to 23 October) to determine presence and relative abundance of fish species and life stages during these two seasons. Each river segment defined for the IFIM study was sampled by gill netting, boat and backpack electrofishing, seine netting, kick sampling and direct observation. Methods of sampling varied with habitat conditions present in each segment. During the fall studies, methods paralleled as nearly as possible those used in the summer.

4.2.1 Gill Netting

Gill netting was conducted in deeper areas of each segment, where velocity was slow enough to prevent net drift. Appropriate sites were limited in summer by low water levels, and in the fall by high velocities. Whenever possible, gill nets were set at the same locations during summer and fall sampling. Net locations are illustrated in Figure 3. Nets were set overnight for approximately 12 hours; orientation was generally perpendicular to shore.

The gill nets employed were all 15.2-m long by 2.4-m deep and constructed of monofilament nylon. Mesh sizes were 3.8, 5.1, 6.4, 7.6, or 8.9-cm stretched measure. The mesh sizes used were partially dependent upon previous knowledge of species distribution; for example, small mesh sizes were used where smaller species or life stages were present. The same or similar mesh sizes were used at sampling stations during both the summer and fall sampling periods. Gill-netting locations, net specifications and length of sets are presented in Appendix I, Table 2.

4.2.2 Electrofishing

A 3 000 watt boat-mounted electrofisher (Smith-Root Model 3.5 GPP) was used to sample fish during the summer and fall. The boat electrofisher was mounted in a 3.8-m inflatable boat (Zodiac) which was powered by a 40HP jet-driven Mercury outboard motor. Effort was recorded in seconds. Use of this electrofisher was restricted to locations where water levels were sufficient for travel by boat.

A backpack electrofisher (Smith-Root Type VII) was used in shallow areas of the river, in particular when high velocity or rough substrate prevented seining. This electrofisher was occasionally used from the inflatable boat when travel with the 3 000 watt boat electrofisher was not possible. Effort was also recorded in seconds. Electrofishing locations are illustrated in Figure 4. Sampling locations, dates and effort for boat and backpack electrofishing are summarized in Appendix I, Tables 3 and 4, respectively.

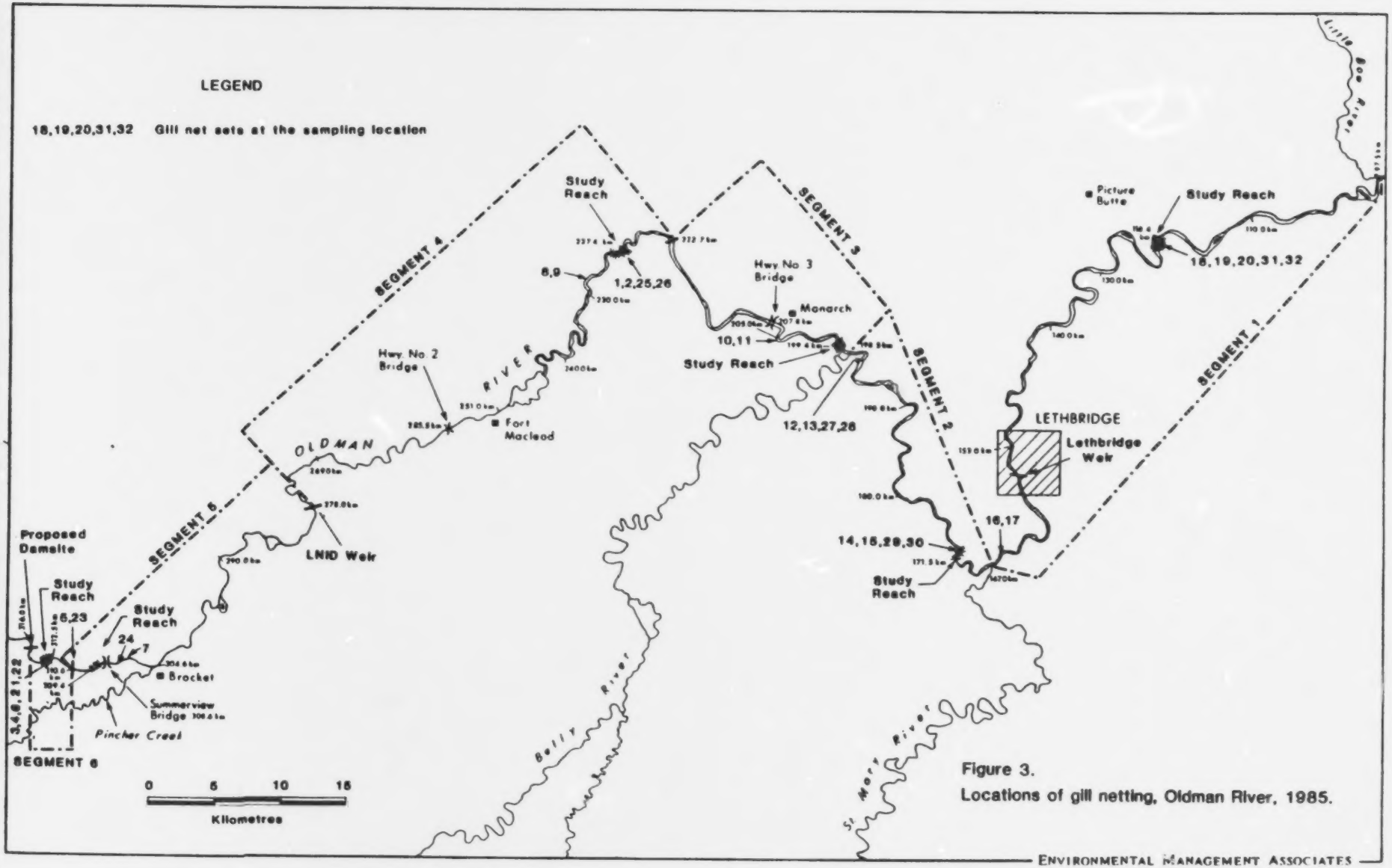

Figure 3.
Locations of gill netting, Oldman River, 1985.

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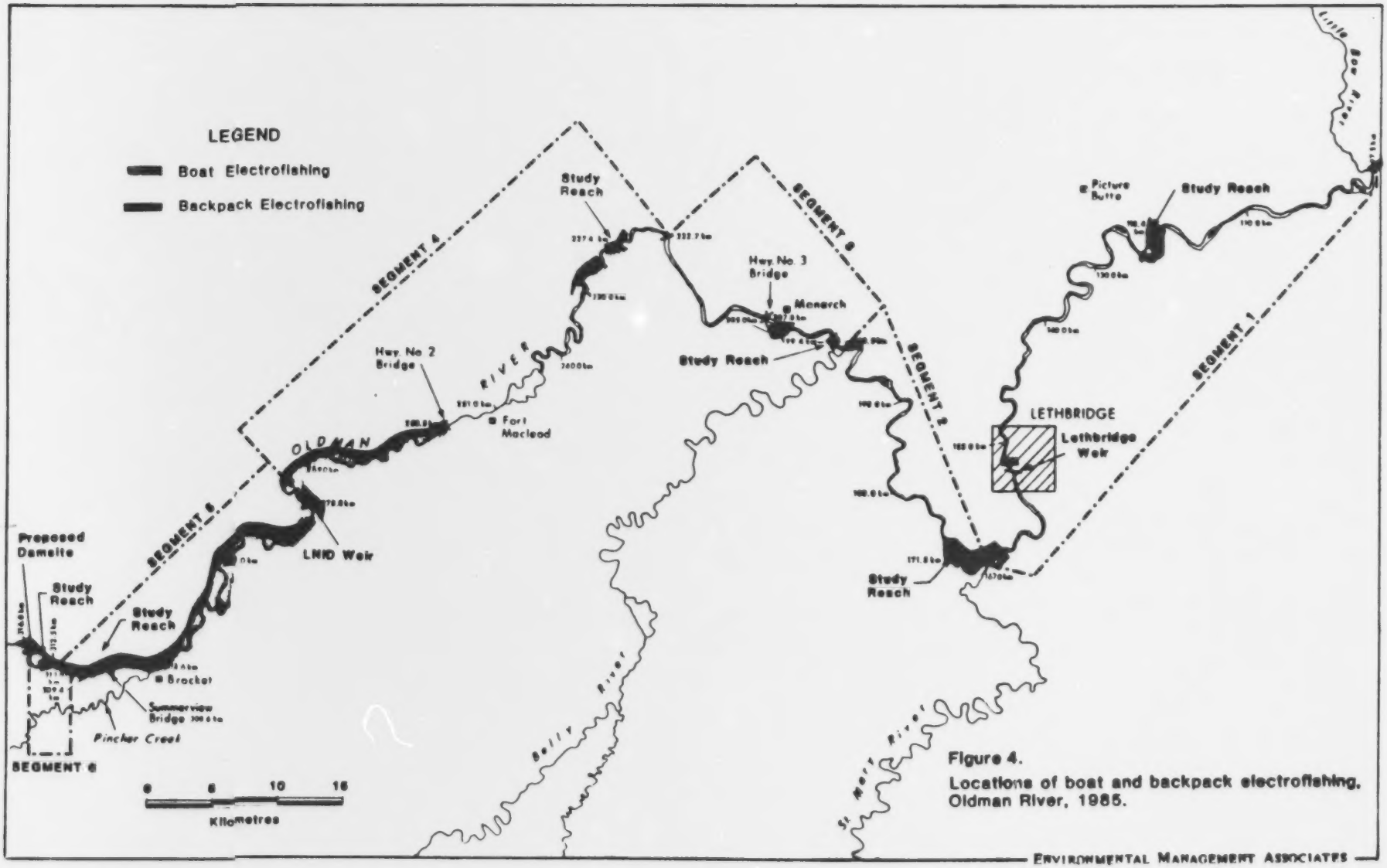

Figure 4.
Locations of boat and backpack electrofishing, Oldman River, 1985.

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4.2.3 Seining

Several beach seines were used to capture fish in the Oldman River during inventory studies; net dimensions may be found in Table 4. Seining was conducted primarily during the summer sampling period, as high water levels often precluded seining during the fall. Seine locations are illustrated in Figure 5. A description of seining locations and efforts is summarized in Appendix I, Table 5.

4.2.4 Direct Observations

Direct observation of fish was used to determine fish presence and relative abundance in study segments where good visibility and relatively shallow depths existed. Underwater observations were carried out using a wet or dry suit, face mask and snorkel while floating downstream. Numbers of each species and life stage observed were recorded, as well as length of river examined. The regions of the river where this sampling technique was employed are illustrated in Figure 5; the sampling effort is summarized in Appendix I, Table 6.

Observations from the surface were made while drifting or travelling in an inflatable boat, or while wading. These types of observations were often incidental to other field work. Numbers of each species and life stage observed, and length of river examined were routinely recorded. The sampling effort for surface observations is summarized in Table 7 of Appendix I.

Surface observations were also carried out from a stationary point to determine whether any migrations were occurring in late August. a complete cross section of river could be seen. Hours of observation and numbers of fish moving downstream and upstream were recorded. The results of this sampling effort are summarized in Appendix I, Table 8.

TABLE 4

DIMENSIONS OF BEACH SEINES USED ON THE OLDMAN RIVER, SUMMER AND FALL, 1985

Length (m)	Depth (m)	Mesh Size (cm)[a]
6.2	1.1	0.8
7.5	1.3	1.1
14.8	3.0	1.4
15.0	2.0	8.9

[a] stretched measure

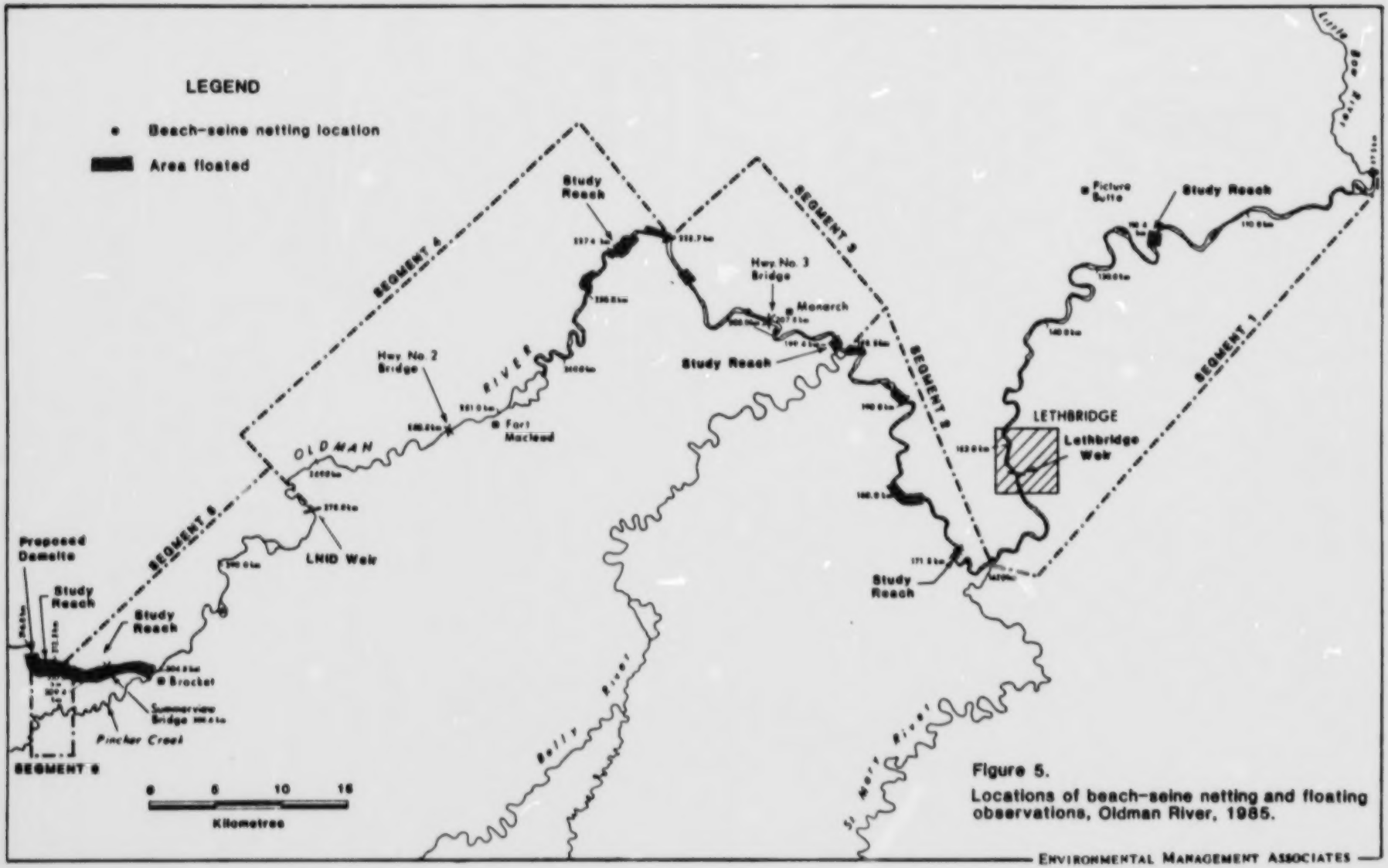

Figure 5.
Locations of beach-seine netting and floating observations, Oldman River, 1985.

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4.2.5 Kick Sampling

Kick samplers (30.5 cm/side, triangular frame) with 5.6 meshes/cm netting were used to locate fertilized mountain whitefish eggs. The samplers were held on the substrate immediately downstream of the site to be disturbed by kicking, or scraping with a paddle if water depth precluded kicking. The area of substrate disturbed was equal to sampler width (30.5 cm) times length of disturbed area, which was standardized at 0.3 m. The number of eggs collected at each site was recorded. Eggs were maintained alive for subsequent diameter measurement. Kick-sampling locations, and areas where eggs were collected in the study area are illustrated in Figures 6 and 7. The record of sampling effort is presented in Appendix I, Table 9.

Kick-sampling results were used to identify mountain whitefish spawning areas, which were found to occur in Segments 4, 5 and 6. The river was sampled extensively by this technique from the proposed damsite downstream to the Summerview Bridge, while the area downstream of the Summerview Bridge to the bridge at Highway 2 was sampled only where adult mountain whitefish had been located previously, and, when time permitted, where habitat appeared suitable.

4.2.6 Fish Handling Procedures

All captured fish were identified to species, and when possible, living specimens were identified to life stage, sex and state of maturity. To provide data for life history analyses, a representative sample of each sport species, preferably already dead or in poor condition, was examined as follows. Each fish was measured (fork length to the nearest mm), weighed with a hand-held scale (to the nearest g), and the sex, life stage, state of maturity and stomach contents determined by internal examination. Categories used to describe sex, life stage, maturity and stomach contents can be found in Appendix I, Table 10. Aging structures were also collected from each fish. A list of structures collected from each species, as well as methods of storage, may be found in Appendix I, Table 11.

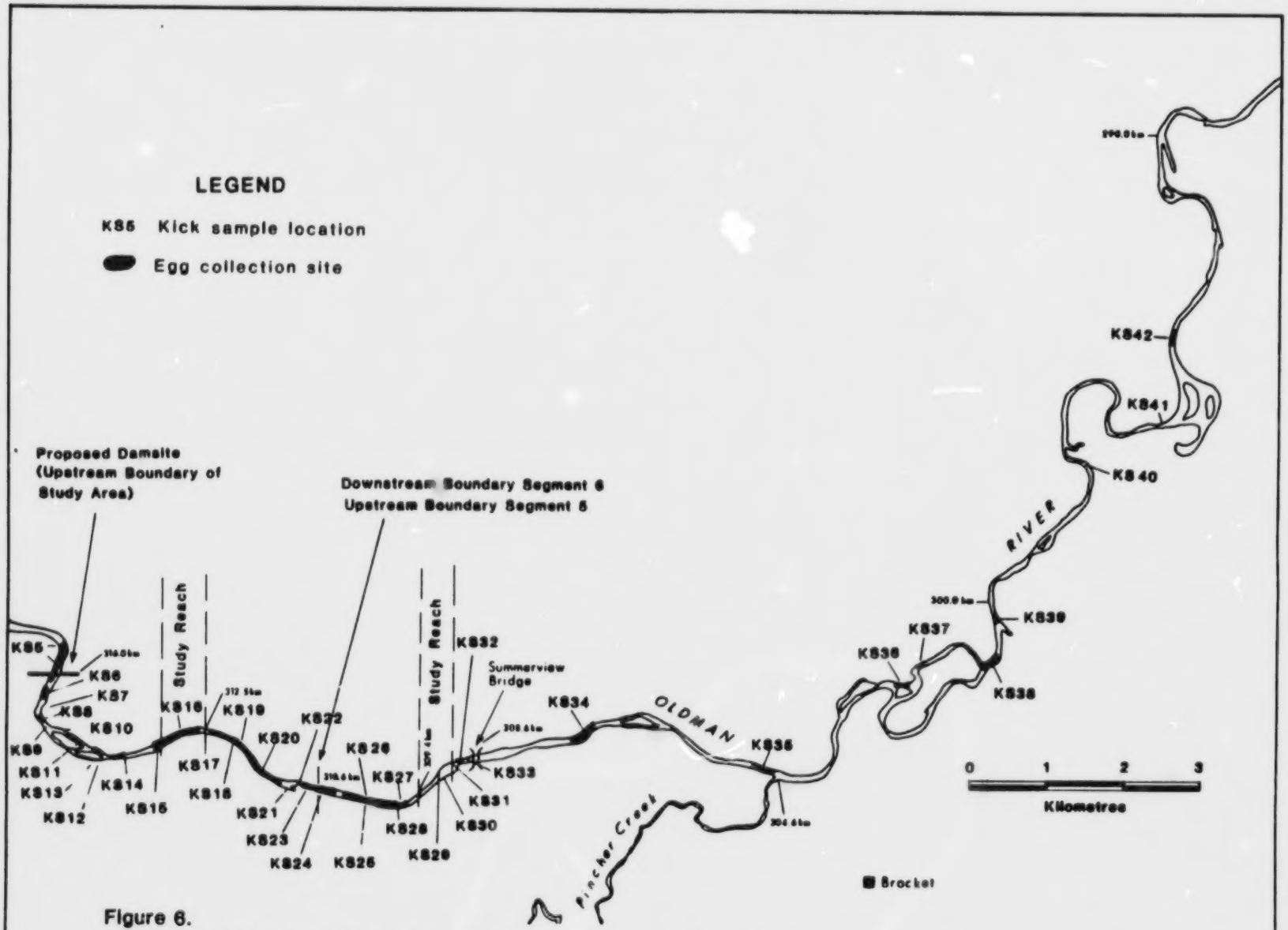

Figure 6.
Locations of kick sampling and egg collection, Segments 5 and 6, Oldman River, 1985.

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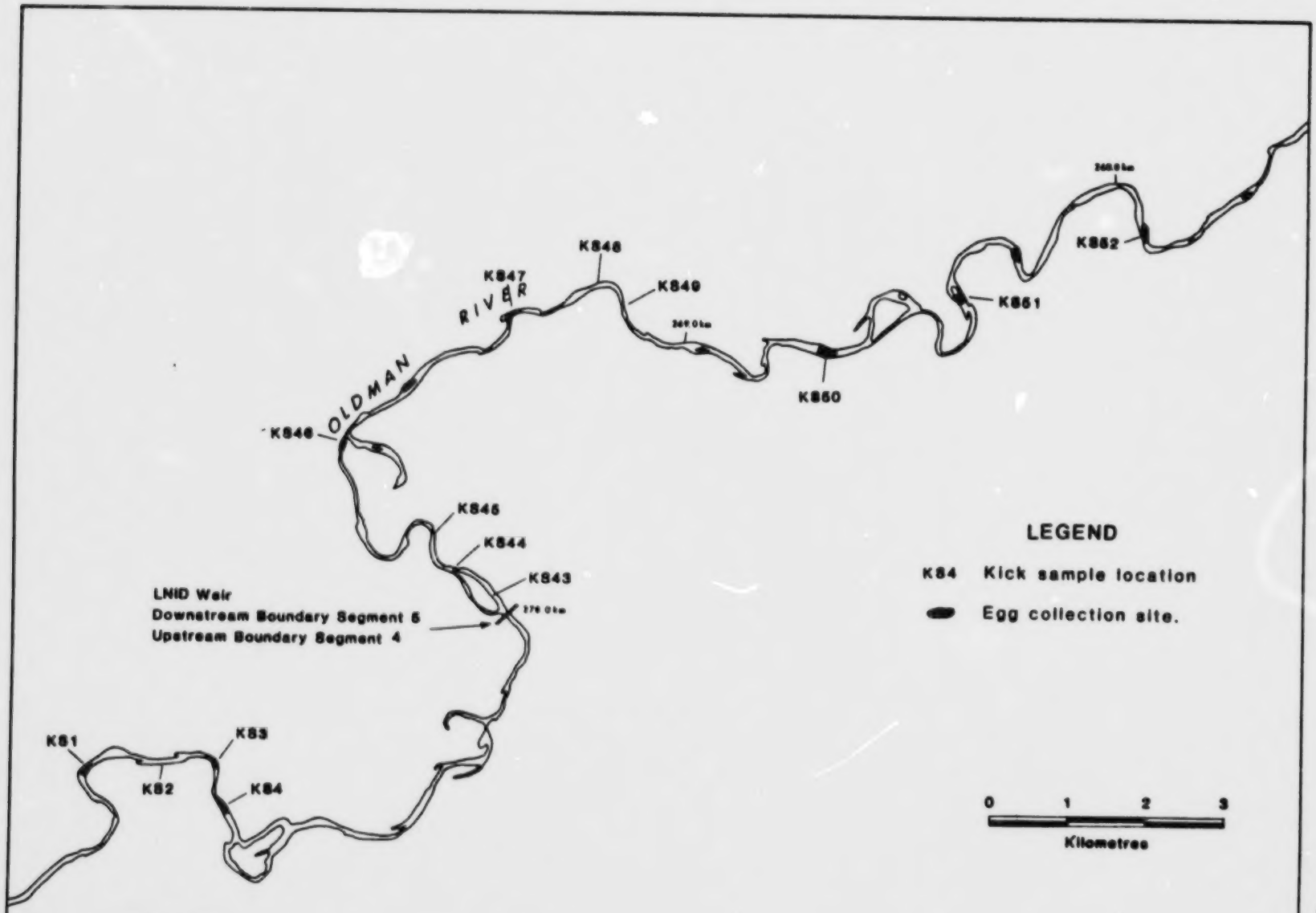


Figure 7.
Locations of kick sampling and egg collection, segments 4 and 5, Oldman River, 1985.

A sample of each life-history stage of mountain whitefish was also measured (fork length and body depth at the front of the dorsal fin, to the nearest mm) to provide data for determining depth of water necessary for fish passage over obstacles.

Some tagging of sport species was conducted to assist in determining fish movements in the river, and passage at weirs. Those fish which were captured in good condition and which were not necessary for life history analyses were marked with numbered floy tags (Model FD68-B) and released. The tags, which offered a $2.00 reward upon return to Alberta Environment, were provided for use by the Planning Division. A summary of fishes tagged is presented in Appendix I, Table 12.

Several mountain whitefish in spawning condition were stripped of eggs and milt; these reproductive materials were combined to provide samples of fertilized eggs. After fertilization, mean egg diameter was determined for eggs from each female. Groups of 30 eggs were measured in a graduated trough, and the result divided by 30 to provide a measure of mean egg diameter. Eggs were maintained live in containers in the river and measured at least once every two days to provide diameters of water-hardened eggs. Sub-samples of these eggs were preserved in Davidson's solution. Egg diameters were determined to confirm the identification of eggs recovered from the substrate.

Eggs collected from the substrate of the Oldman River by kick sampling were also measured (diameter) by the same method. The results of egg measurements are summarized in Appendix I, Table 13.

4.2.7 Age Determination

Age determination of salmonid species, mooneye and burbot was done using otoliths whenever possible. To increase clarity of annular rings, the lateral surface of otoliths was first ground on a fine-grit carborundum stone to the depth of the nucleus. After grinding, otoliths

were placed in a petri dish filled with xylene. Otoliths were viewed under reflected light using a binocular microscope at 12.5X magnification. Each annulus, consisting of an opaque and a hyaline ring, was counted as one year of growth.

Bony structures were used for age determination of walleye and sauger (finrays), and northern pike (cleithra). All flesh and connective tissue was removed from these structures by submerging them in hot water and teasing or wiping tissue away from bone. Annular rings of cleithra were counted both with a microscope (12.5X magnification) and with the naked eye. Finrays were embedded in epoxy and sectioned at the base using a jewelers saw. Sections were placed on a glass slide and viewed using a microscope at 12.5X magnification. Each annulus consisting of an opaque and a hyaline ring was counted as one year of growth.

Those individuals from which otoliths or bony structures were not available were aged using scales. Scales were viewed under transmitted light using a Bell and Howel Model 100A microfiche projector at 42X magnification. Each annulus was counted as one year of growth. Several scales from each fish were used to compare annuli counts. If any discrepancy of counts occurred, the most frequently obtained count was used.

4.2.8 Data Processing

All data were recorded directly in field books, and transcribed daily to 80 column computer data sheets while in the field. Data were input to a microcomputer system programmed for validation of the input data. Storage of all data was on 9-track magnetic tapes or microcomputer floppy disks, and in printed form.

Catch-Per-Unit-Effort (CPUE) calculations were done by computer. The formulae employed to calculate these statistics were: electrofishing - number of fish captured/100 seconds of electrofishing; beach seining - number of fish captured/100 m^2 of surface area sampled; gill netting (per

net) - number of fish captured/hour of sampling; direct observation - number of fish observed/100 m length of stream studied; and kick sampling - number of eggs collected/m^2 of substrate sampled.

5.0 RESULTS

5.1 INSTREAM FLOW INCREMENTAL METHODOLOGY RESULTS

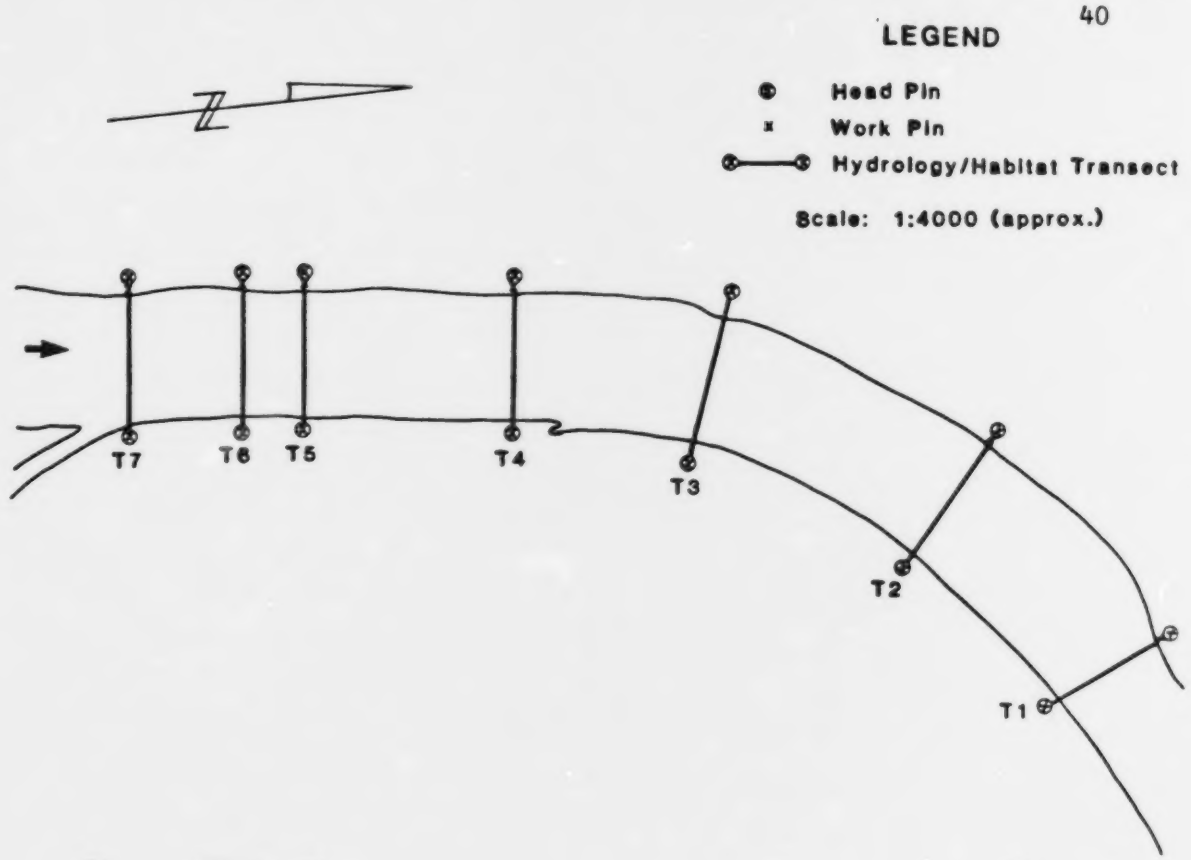
5.1.1 Stream Hydrology and Available Habitat

A sketch, photograph and aerial photograph of each of the six representative reaches in the study area are presented in Figures 8 through 19. The numbers and locations of transects at each representative reach are illustrated on the sketches and aerial photographs.

The data collected during the hydrologic and habitat components of the study are currently calibrated and stored on tapes which have been presented to the Planning Division. Stage-discharge relationships and cross-section plots of each transect in each reach are presented in Appendix II.

The available habitats for mountain whitefish fry, juveniles, and adults and rainbow trout juveniles during late June and early July (i.e., the times at which hydrologic measurements were carried out) are summarized in Table 5. Estimates of weighted usable area (WUA) are only presented for those river segments where life-history stages of the two species actually occurred during the study. The mountain whitefish spawning/egg incubation WUA is presented for Segments 4, 5 and 6, using the flow rates measured in June and July, as no measurements were carried out during the October spawning period due to high river stages. The habitat preference curves employed in developing these estimates of available habitat are presented in Section 5.1.2.

Diagrams of the two weirs in the study area, which were identified as critical reaches, are presented in Figures 20 and 21. The results of the analysis involving flow records from the WSC gauge at Lethbridge and the weir elevation in Lethbridge are presented in the form of a stage-discharge relationship at the weir. The relationship plotted in Figure 22 illustrates both river stage and water depth over the weir as a function of



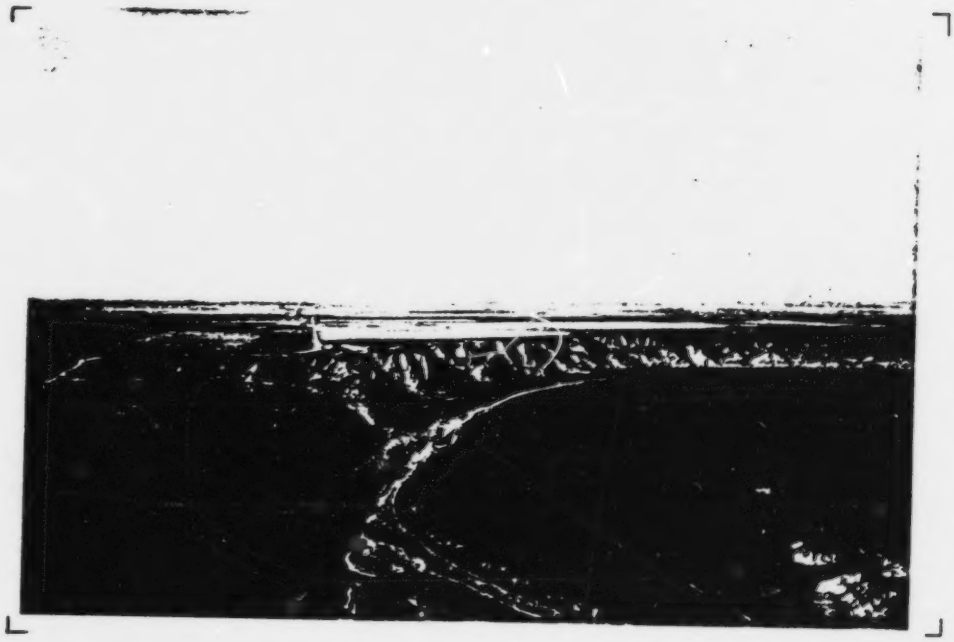
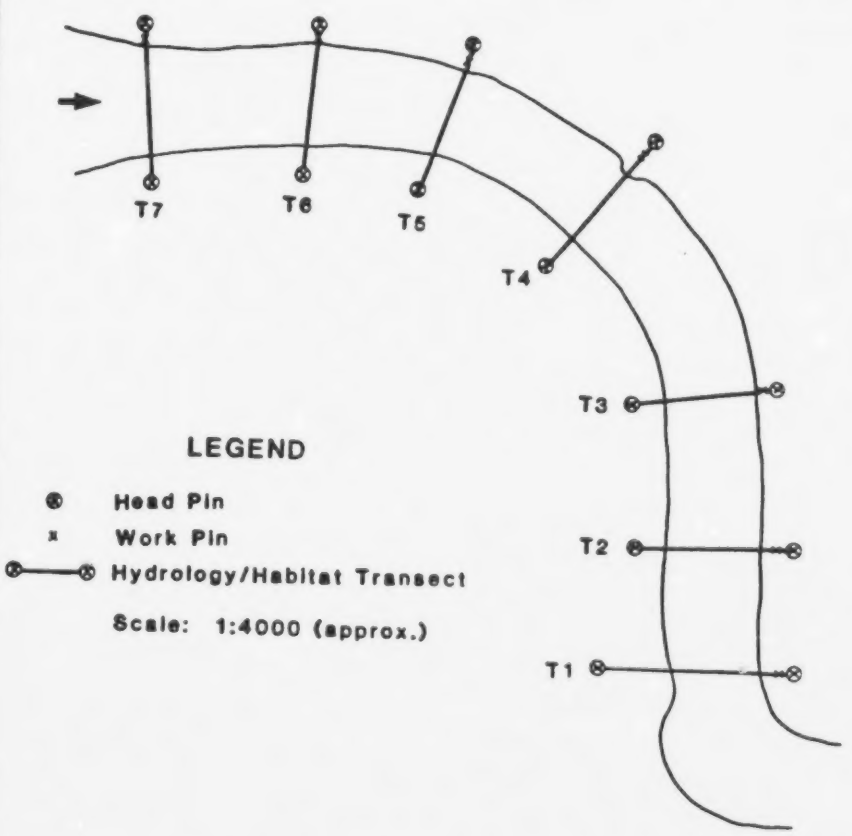


Figure 8. Representative Reach, Segment 1.

Figure 9. Aerial photograph of Representative Reach, Segment 1.



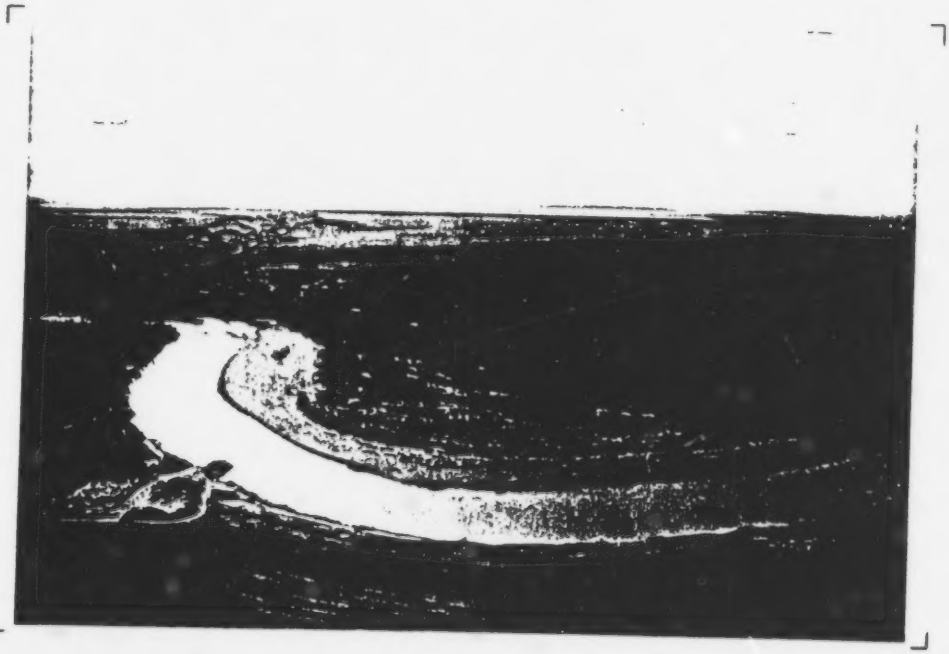
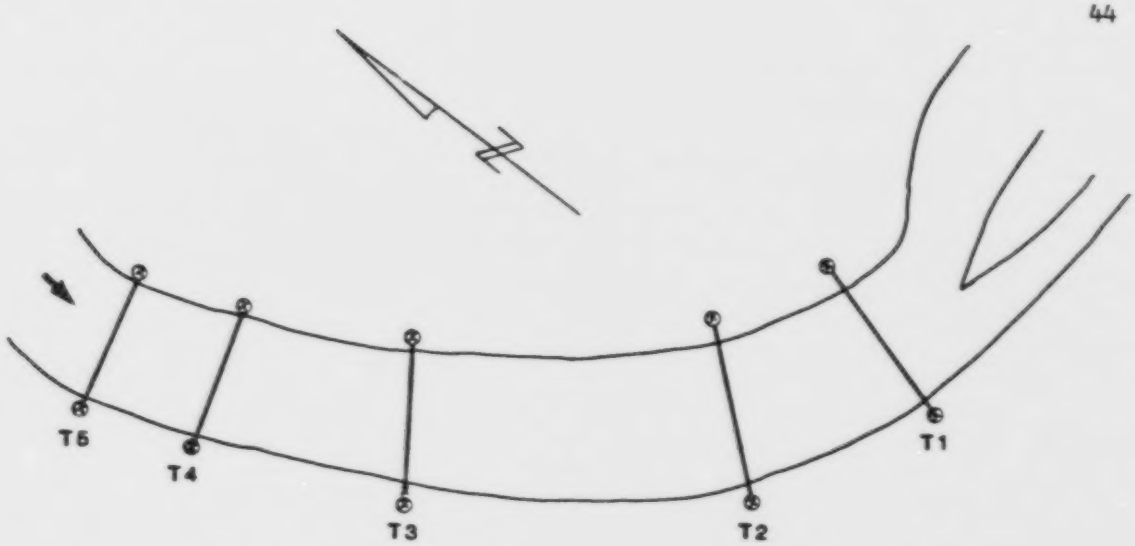


Figure 10. Representative Reach, Segment 2.

Figure 11. Aerial photograph of Representative Reach, Segment 2.



LEGEND

⊗ Head Pin

× Work Pin

⊗——⊗ Hydrology/Habitat Transect

Scale: 1:4000 (approx.)

Figure 12. Representative Reach, Segment 3.

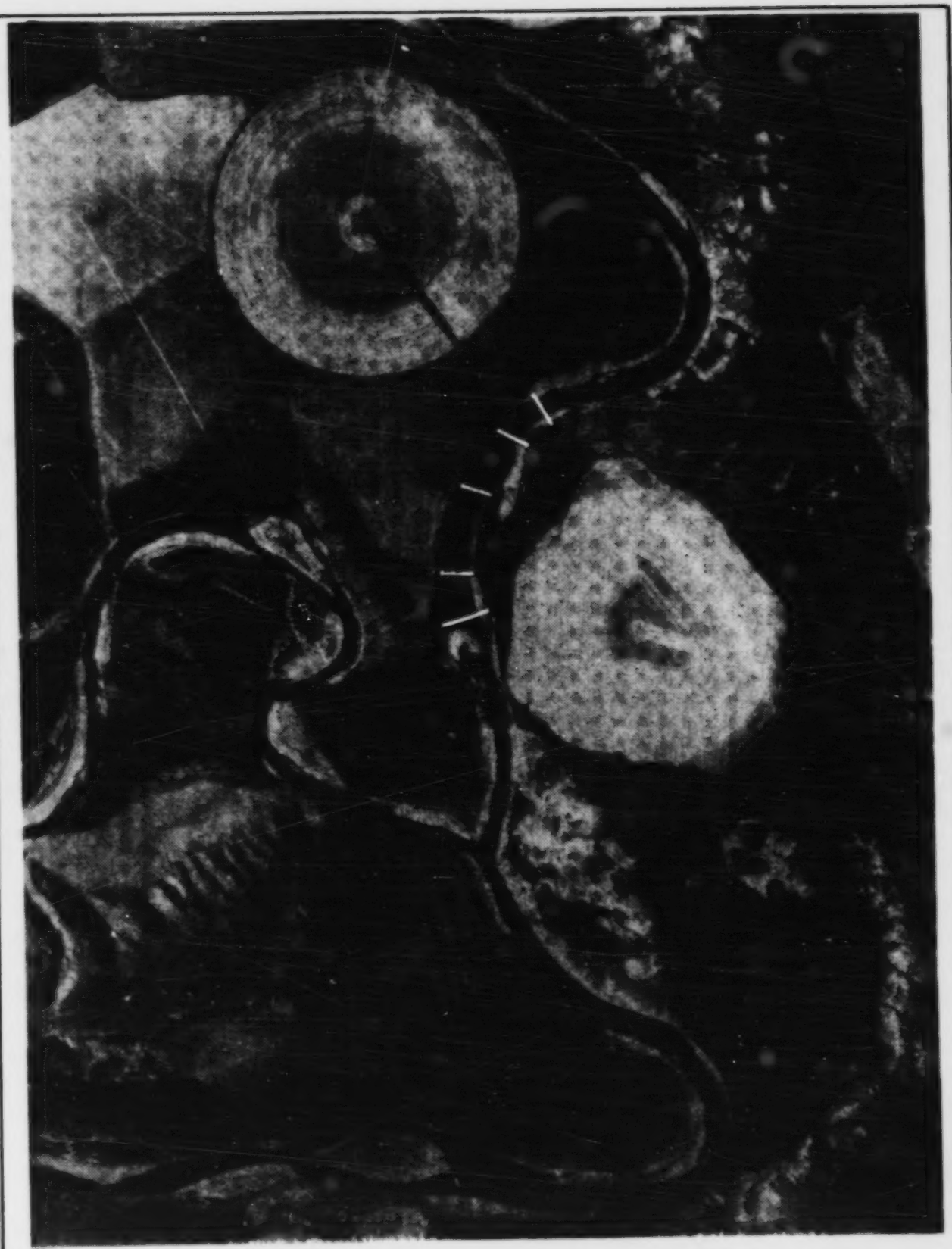
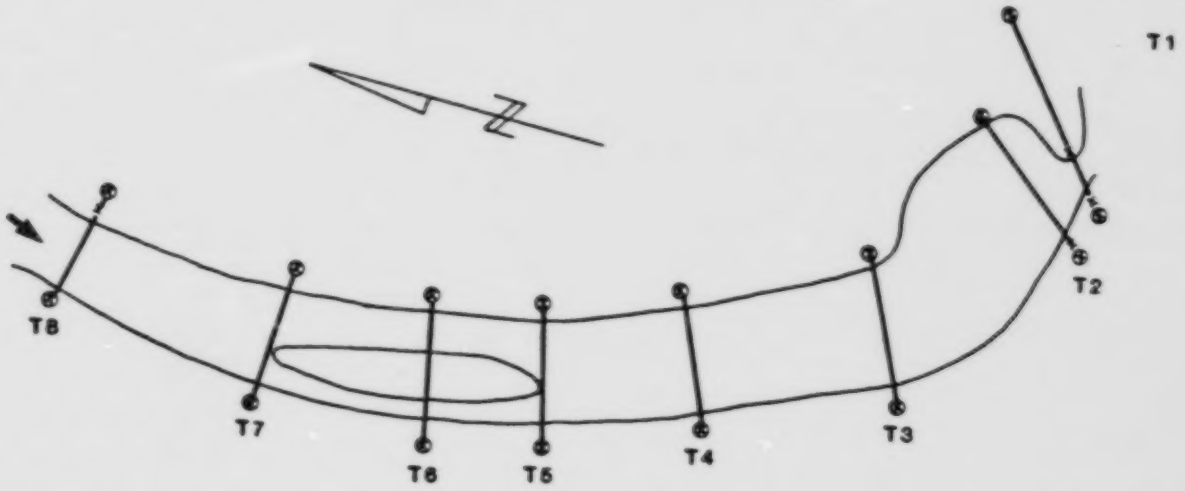


Figure 13. Aerial photograph of Representative Reach, Segment 3.



LEGEND

⊗ Head Pin

× Work Pin

⊗——⊗ Hydrology/Habitat Transect

Scale: 1:4000 (approx.)

Figure 14. Representative Reach, Segment 4.

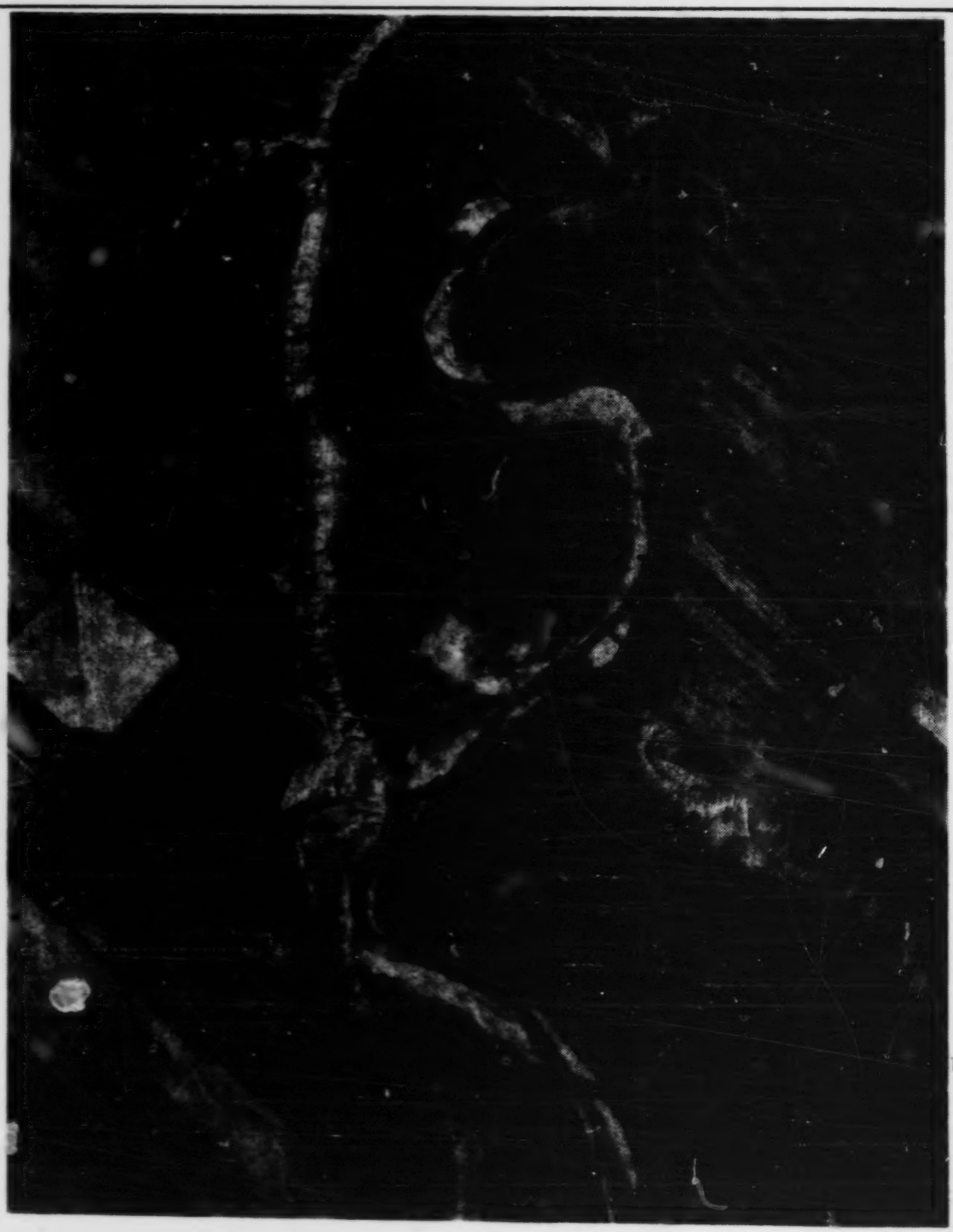
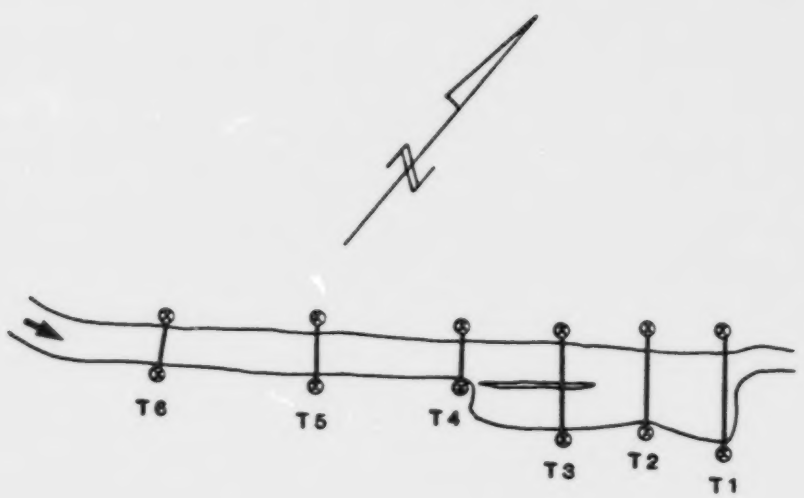


Figure 15. Aerial photograph of Representative Reach, Segment 4.



LEGEND

- Head Pin
- Work Pin
- Hydrology/Habitat Transect

Scale: 1:4000 (approx.)

Figure 16. Representative Reach, Segment 5.

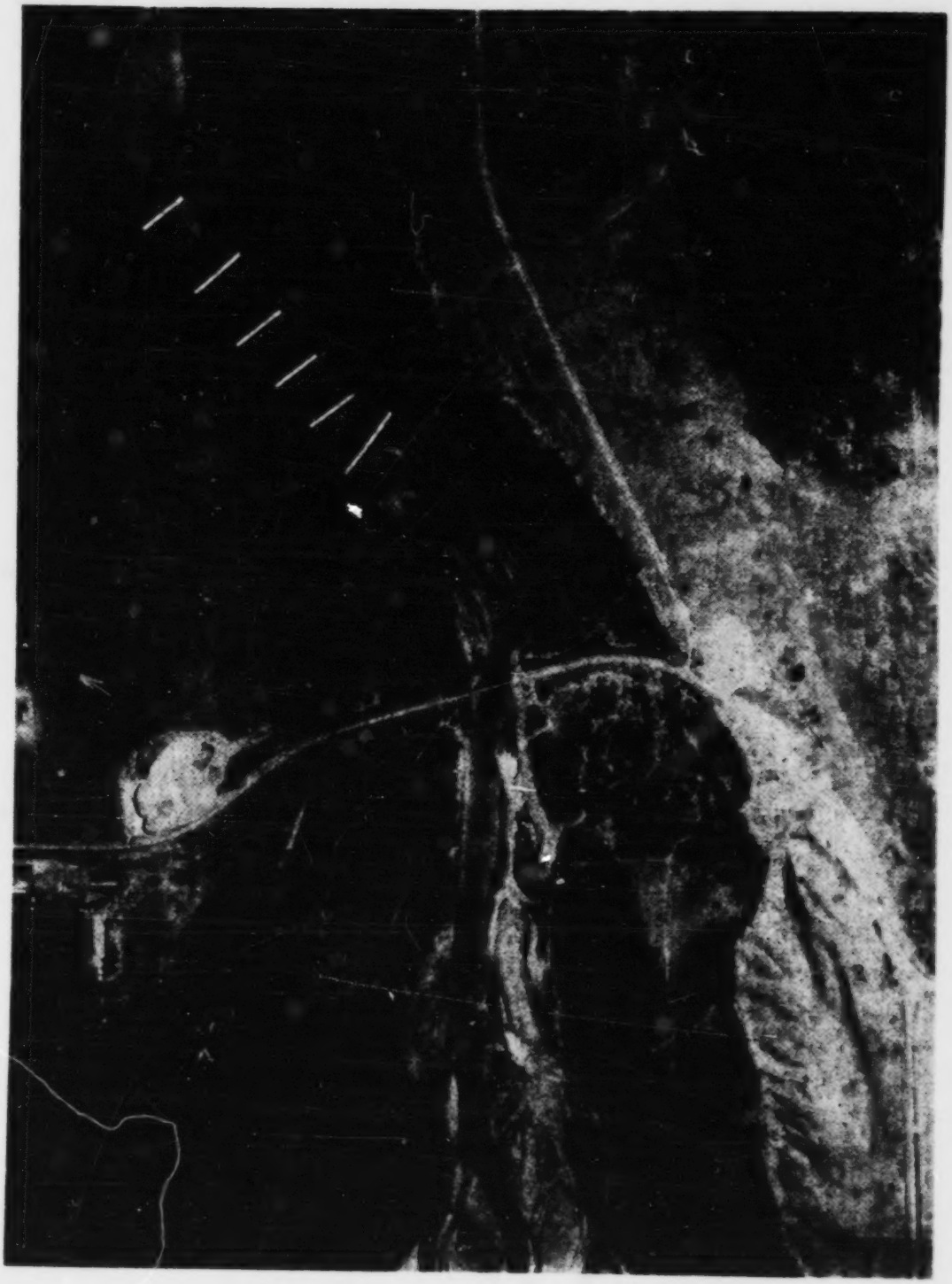
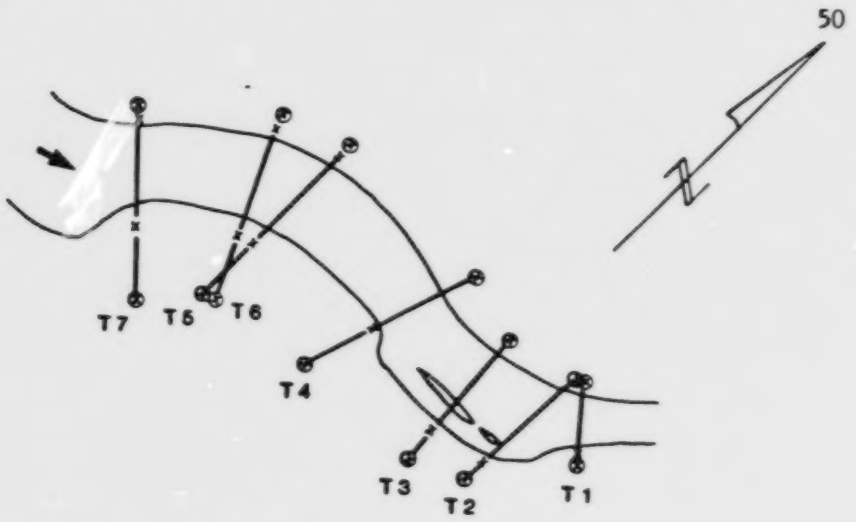


Figure 17. Aerial photograph of Representative Reach, Segment 5.



LEGEND

- HEAD PIN
- WORK PIN
- Hydrology/Habitat Transect

Scale: 1:4000 (approx.)

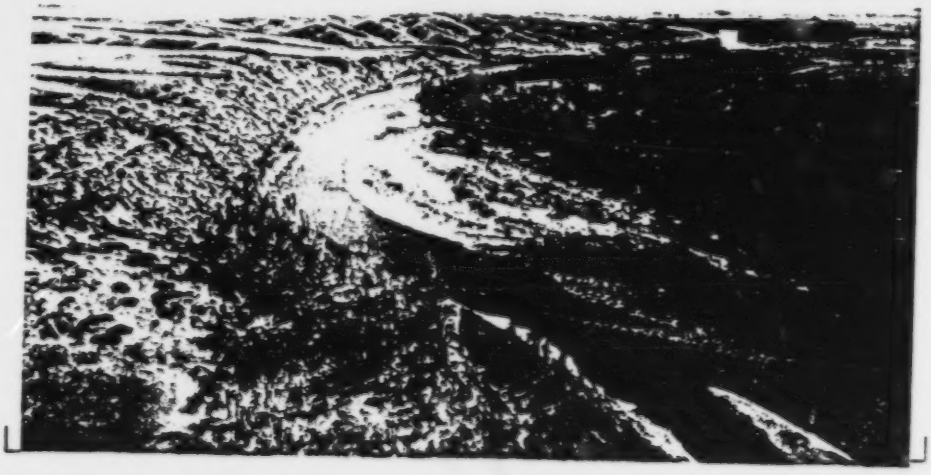


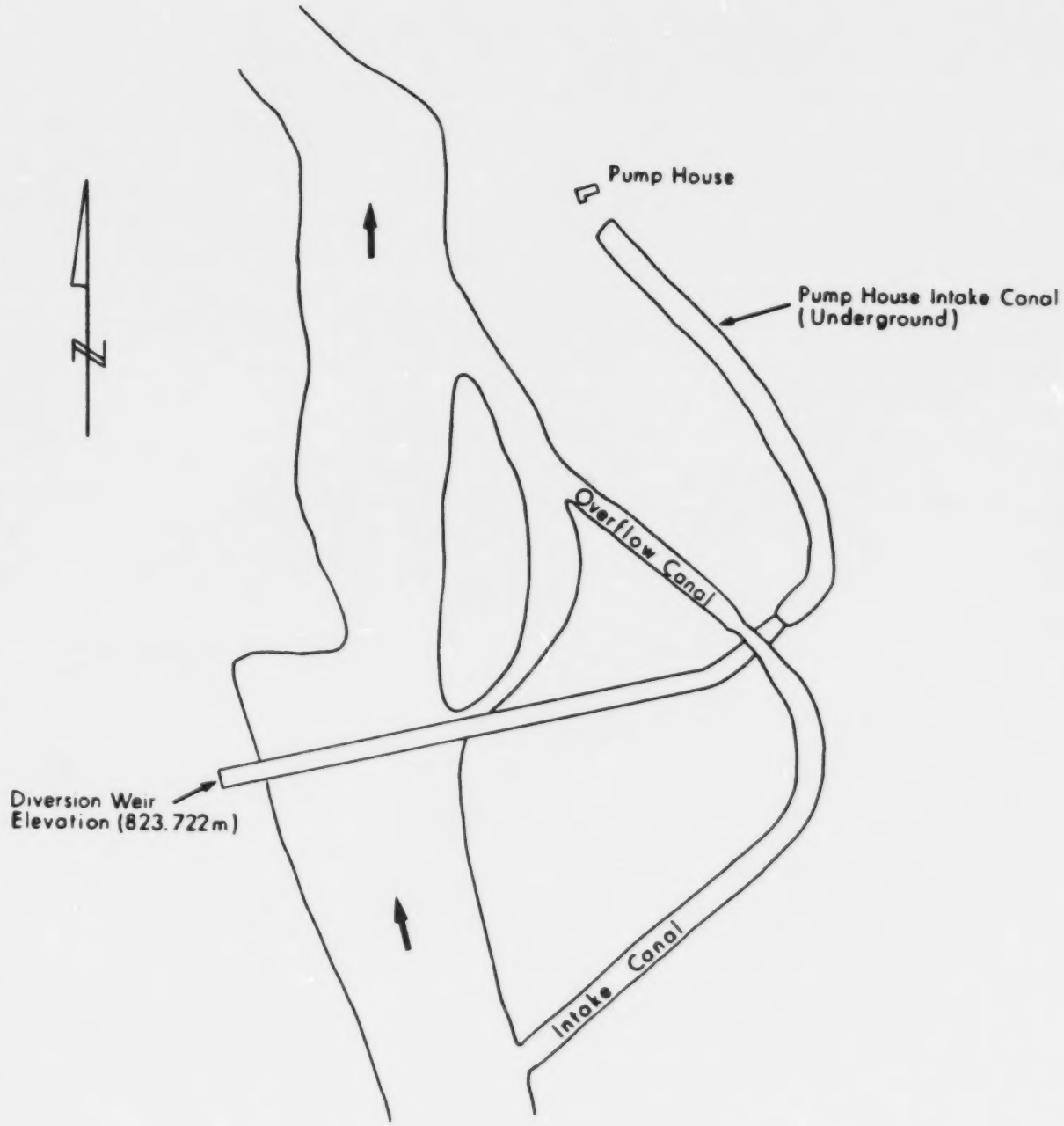
Figure 18. Representative Reach, Segment 6.

Figure 19. Aerial photograph of Representative Reach, Segment 6.

TABLE 5

WEIGHTED USABLE AREA AT MEASURED FLOWS WITHIN THE OLDMAN RIVER STUDY AREA, 1985

Segment	Segment Length (km)	Month	Discharge (m^3/s)	Weighted Usable Area (m^2)				
				Mountain Whitefish				Rainbow Trout
				Fry	Juvenile	Adult	Spawning	Juvenile
1	69.5	Jun	61.38	286 097	797 964	1 389 729		
		Jul	10.55	1 060 104	306 516	467 971		
2	31.5	Jun	40.41	150 595	418 868	717 784		
		Jul	6.09	298 913	101 770	137 664		
3	24.2	Jun	28.22	199 882	234 554	351 899		
		Jul	9.60	242 886	138 436	163 926		
4	55.3	Jun	21.39	556 335	527 203	698 760	659 701	929
		Jul	5.57	281 505	189 596	237 635	256 830	3 191
5	32.6	Jun	30.86	144 607	234 423	554 549	402 528	8 218
		Jul	20.85	162 886	192 043	395 180	338 730	7 009
6	5.4	Jun	35.96	14 982	17 844	55 045	26 502	3 728
		Jul	20.95	16 112	15 055	42 687	28 069	2 640



Scale 1:1200 (approx.)

Figure 20. Critical Reach, Lethbridge Weir.

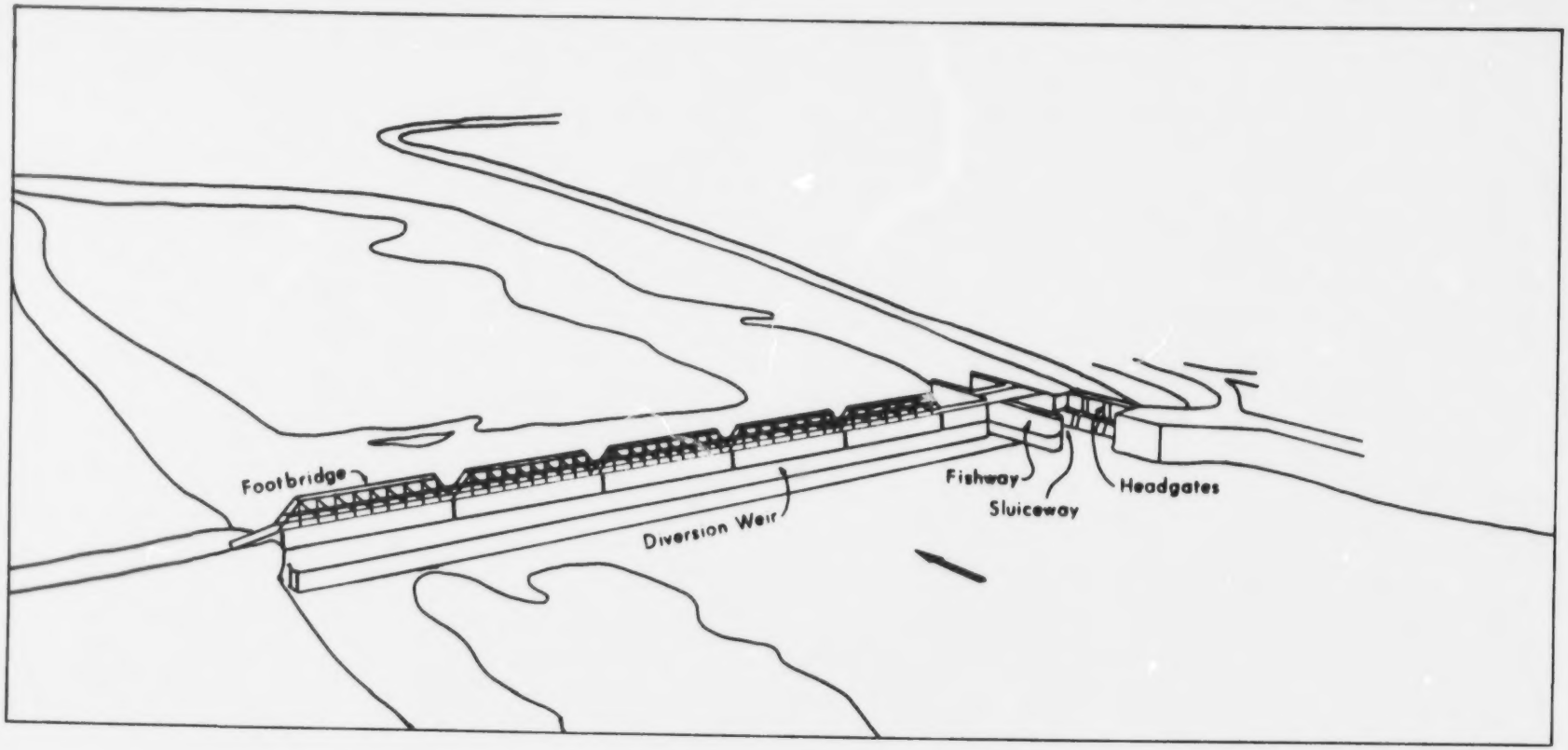


Figure 21. Critical Reach, Lethbridge Northern Irrigation District Division Headworks.

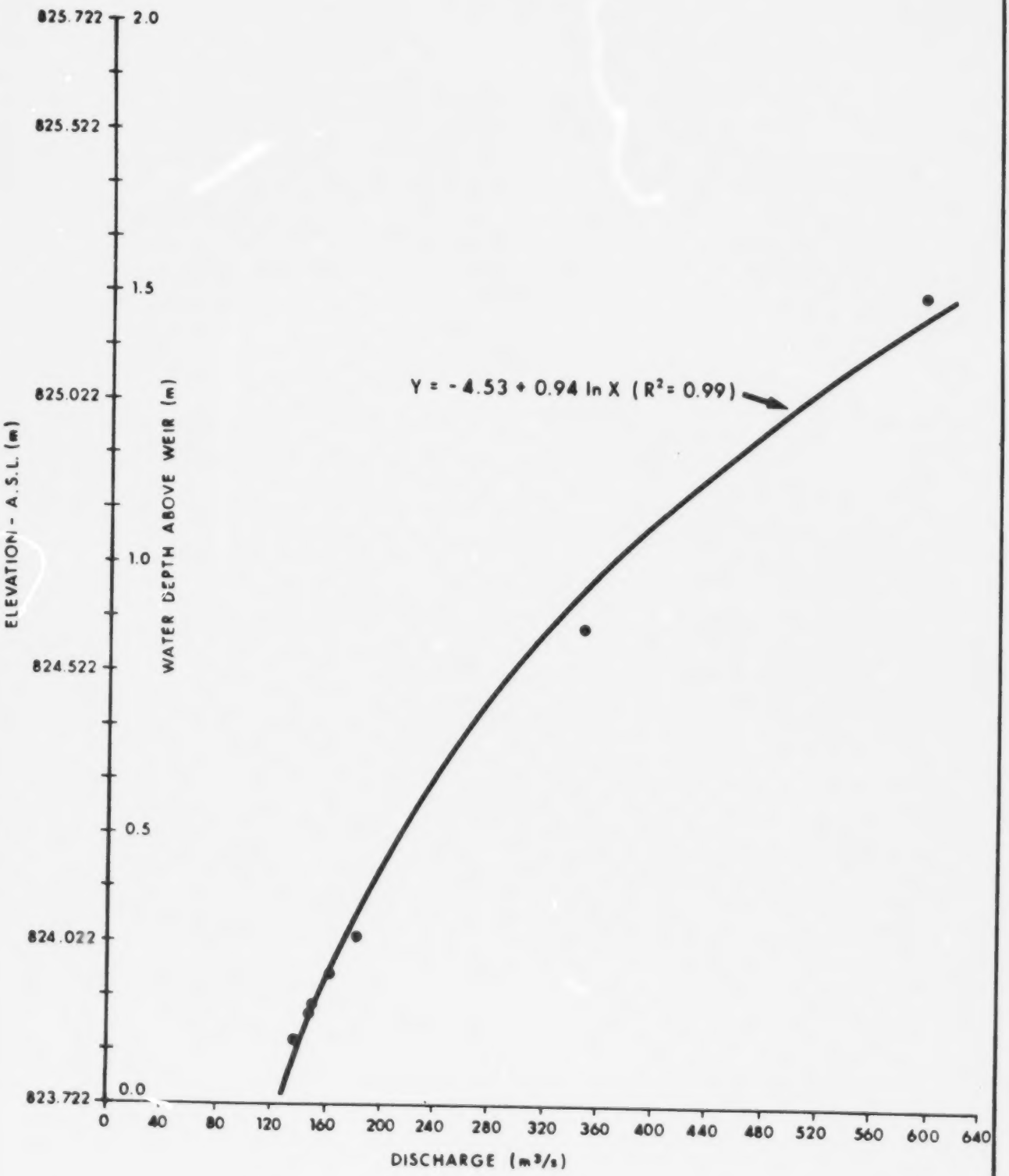


Figure 22. Water depth at river stage, Lethbridge Weir.

flow rate. In addition to this analysis, mean cross-sectional velocities from a range of discharge measurements conducted by WSC personnel at the WSC gauge were examined. These velocities would likely underestimate those which would actually occur at the weir, as the flat uniform structure of the weir would likely result in a higher water velocity at this point. The relationship between discharge and velocity at the WSC gauge is illustrated in Figure 23.

The minimum recommended clearance requirement for fish navigating a barrier has been reported as no less than two-thirds of the body thickness of the fish (Bovee 1982). Measurements of body thickness were carried out for several species of fish during sampling efforts in the fall of 1985. The only species for which a substantial number of measurements could be made was mountain whitefish. Body depth of juveniles (N=51) ranged from 25 to 60 mm while the mean body depth was 42.04 mm ($\pm$ 7.99). Two-thirds of this mean is approximately 28 mm. The body depth of adult mountain whitefish (N=87) ranged from 37 to 105 mm; the mean body depth of this life stage was 58.25 mm ($\pm$ 12.85). The two-thirds body depth criterion for passage of adult mountain whitefish would be a depth of approximately 39 mm. It is apparent that these depth criteria would not likely be sufficient for species such as walleye, sauger or sturgeon. Minimum depth requirements identified from the literature include 0.18 and 0.12 m for large migratory trout and other migratory trout, respectively (Thompson 1972), and 1.52 m for landlocked white sturgeon (White 1976). Various passage velocity requirements of several species of fish endemic to the Oldman River are summarized in Table 6.

As the LNID diversion weir has a fishway incorporated into the headworks, which is not a run-of-the-river fishway, this structure may be operated to allow fish passage at all but the lowest flows in this region of the river.

5.1.2 Habitat Preference Curves

The habitat preference curves employed in computing the WUA

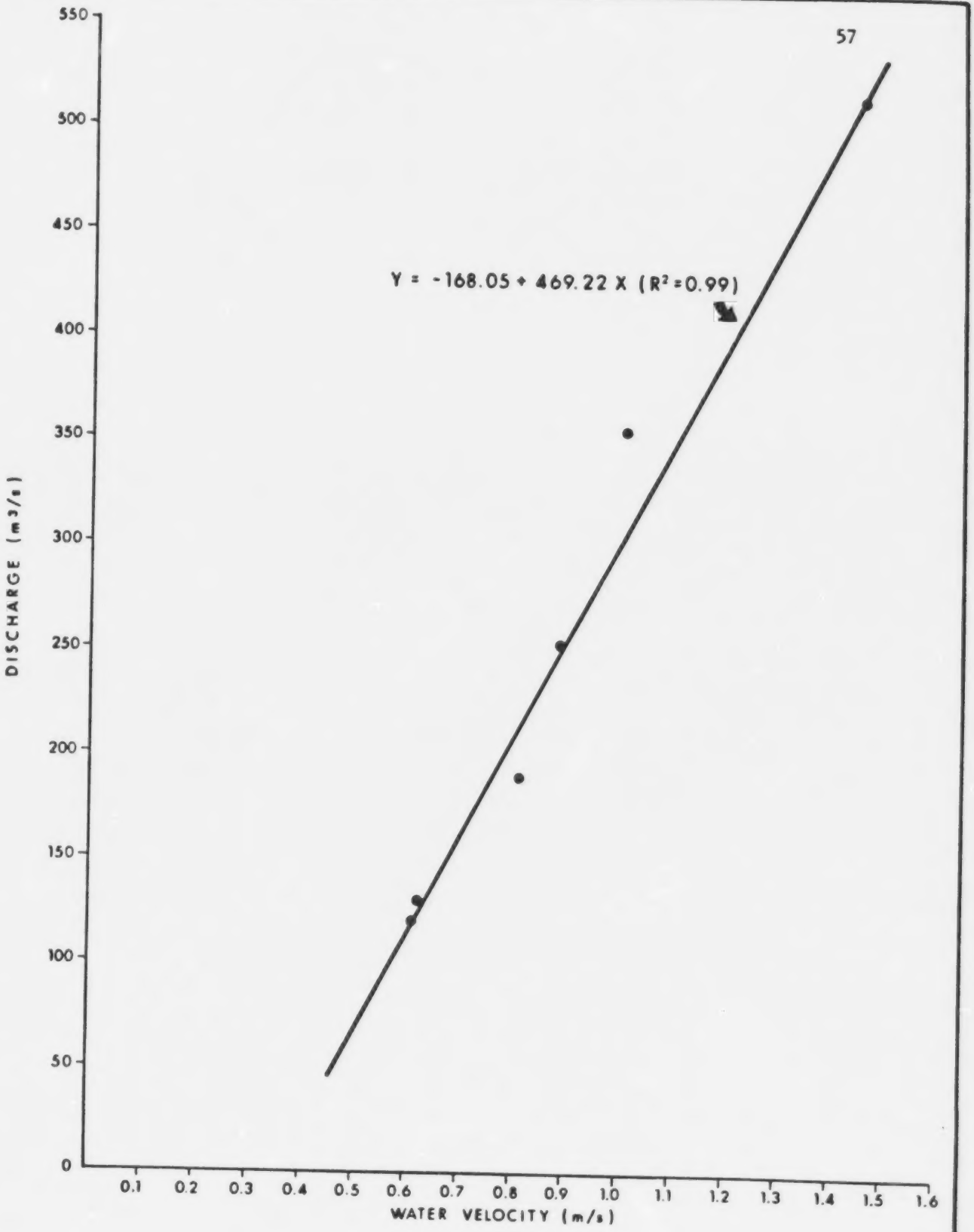


Figure 23. Mean cross-sectional water velocity at various river stages, Oldman River at Lethbridge.

TABLE 6

REPORTED VELOCITY PASSAGE REQUIREMENTS FOR SOME FISHES IN THE STUDY AREA

Species	Estimated maximum swimming velocity (m/s)[a]	Mean[b]		Length (L)-Critical Velocity (CV) regression[b]	Passable hydraulic head (m)[d]	Maximum Velocity (m/s)	Burst swimming speed (m/s)
		Fork Length (mm)	Critical Velocity (m/s)				
Walleye				$CV = 13.07 \times L^{0.51}$			
Mountain whitefish	1.402 ("whitefish")	304 ±15	0.425 ±0.0065				1.31-2.71 ("whitefish")[f]
Northern pike	1.92			$CV = 4.9 \times L^{0.55}$			3.60-4.50[f]
Rainbow trout	3.47 ("trout")	305.8 ±12.7 328[c]	0.666 ±0.063 0.91[c]			1.22[e] 6.42[c]	1.86-8.17[c]
Burbot				$CV = 30.6 \times L^{0.07}$			
Longnose sucker	2.62			$CV = 11.03 \times L^{0.53}$			1.58-3.11[f]
White sucker	2.62			$CV = 10.03 \times L^{0.55}$			1.58-3.11[f]
Goldeye		225	0.60		0.7-0.9		

[a] F.F. Slaney and Company Ltd. (1972).
[b] Critical velocity = maximum velocity that can be maintained for 10 minutes (Jones et al. 1974).
[c] Beamish (1978).
[d] Kristensen and Summers (1978).
[e] Thompson (1972).
[f] For average-sized adults (Fisheries and Oceans 1980).

described in Section 5.1.1 were developed from direct observation of fish, and habitat measurements at that point in the watercourse. The relationships between habitat characteristics and frequency occurrence of life stages were then corrected for availability of habitat at the time of observations, as predicted through the use of the HABTAT program in PHABSIM.

Data were collected during both habitat studies (i.e., the hydrology component) and fish observation investigations regarding available cover and use of that cover by fishes. However, available cover in the river was virtually all associated with substrate particles. This use of cobbles and boulders for cover may largely be a result of a lack of other cover types (i.e., undercut banks, root wads). Therefore, as habitat preferences for substrate type were being identified for the sport fishes of interest, and this preference would inherently include cover considerations, no separate preference curves were developed solely on the basis of cover.

For each curve generated in the present study, the basis on which the curves were developed are presented graphically. That is, each figure presents the habitat preferences of the life stage under consideration, the distribution of the habitat characteristics under consideration, and the ultimate preference curve prepared as a result of correcting for habitat availability. A summary of information collected at fish observation locations for all species is presented in Appendix II.

The habitat preferences for mountain whitefish fry, based on 107 measurements and a total of 720 fry observations, are presented in Figures 24, 25 and 26. The distribution of substrate types and the substrate types at which fry were observed was calculated through the use of a weighted average of the coding applied to each substrate-type category. Although a category was included for detritus (Code 0), no detritus was recorded in the study area. This category was subsequently eliminated from the analysis. The codings employed in the study are as follows: 1 = clay/silt; 2 = sand; 3 = small gravel; 4 = medium gravel; 5 = large gravel; 6 = small cobble; 7 = large cobble; 8 = small boulder; 9 = large boulder; and,

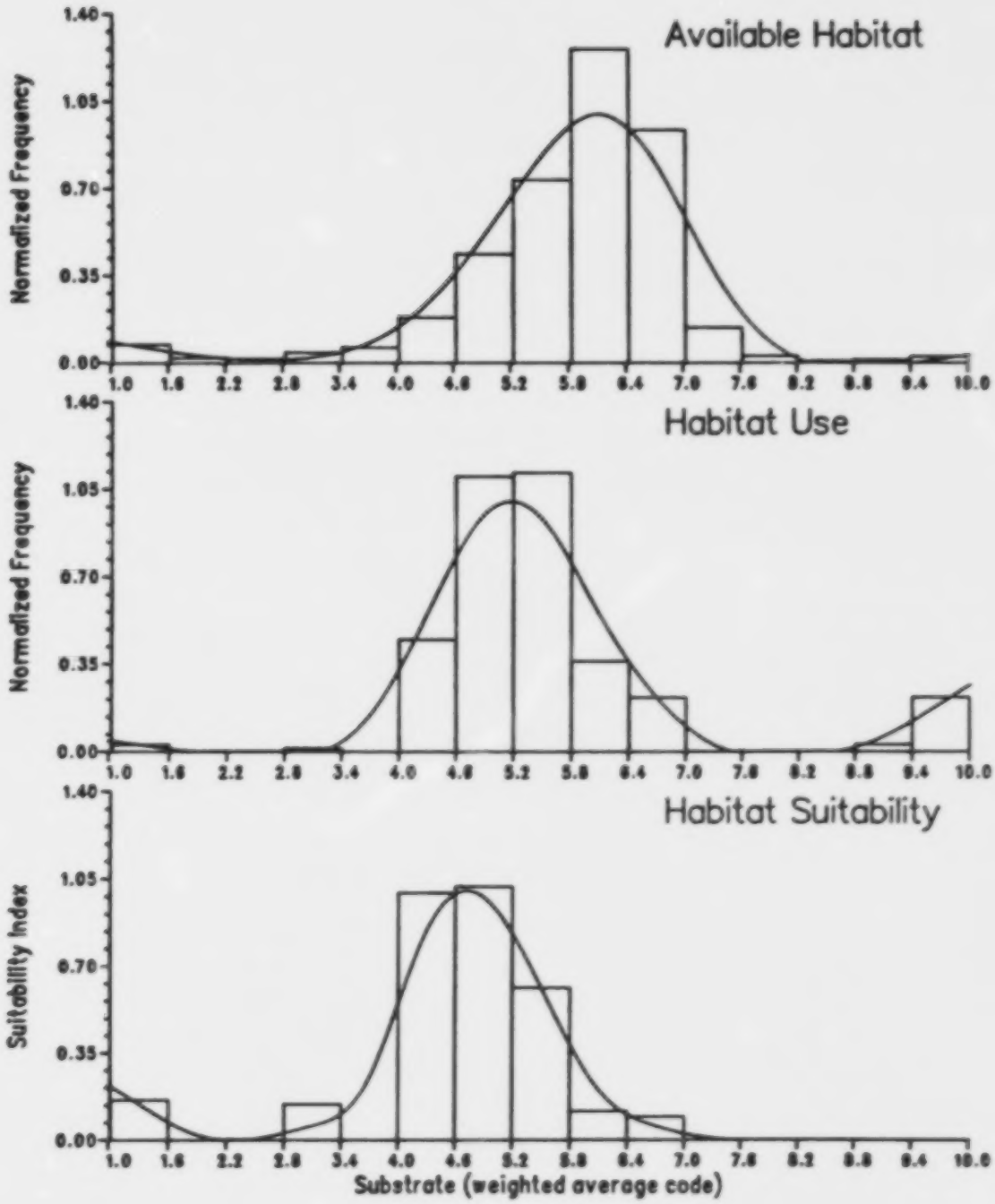


FIGURE 24 Available substrates, substrate utilization and substrate preference curves for mountain whitefish fry.

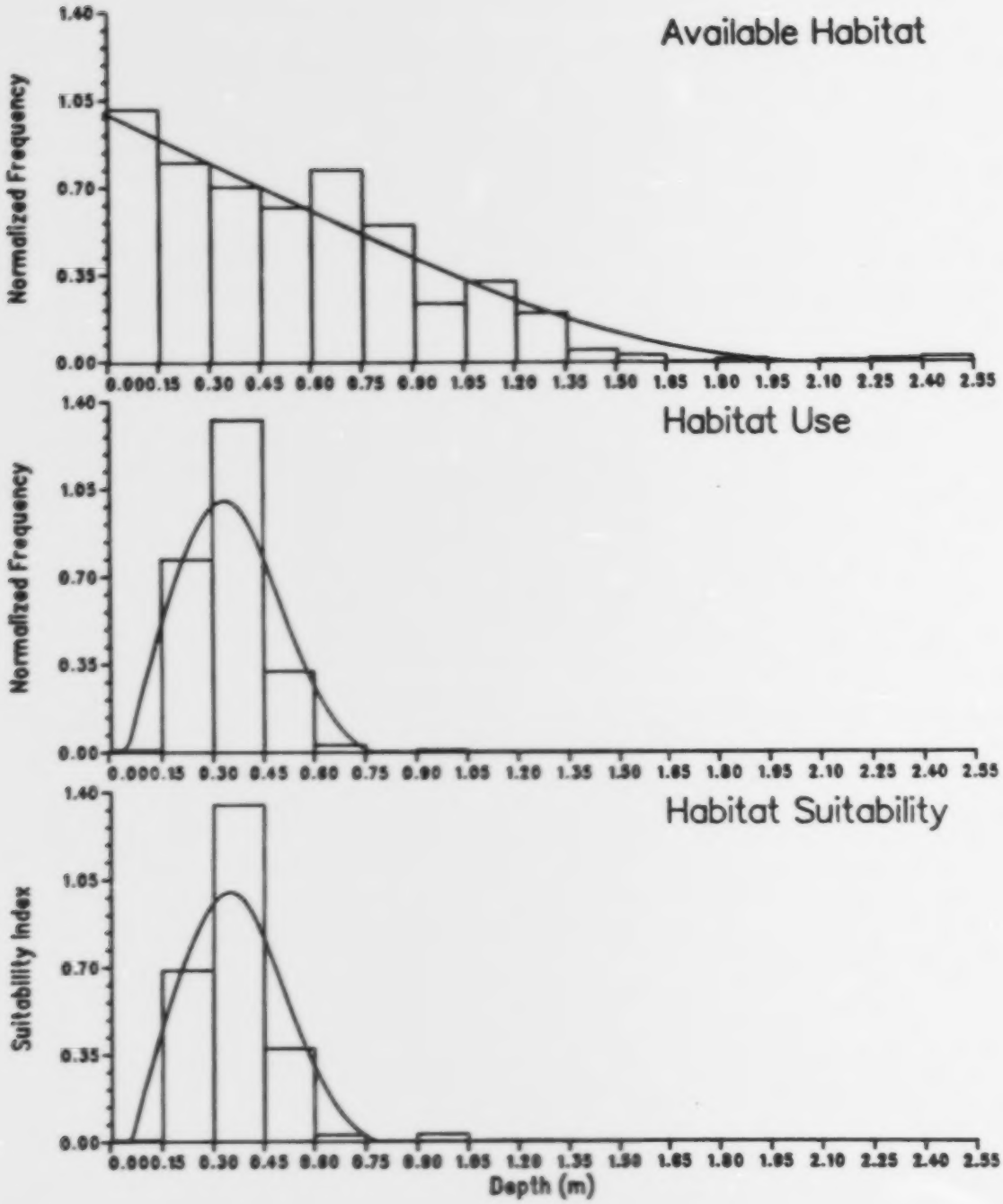


FIGURE 25 Available depths, depth utilization and depth preference curves for mountain whitefish fry.

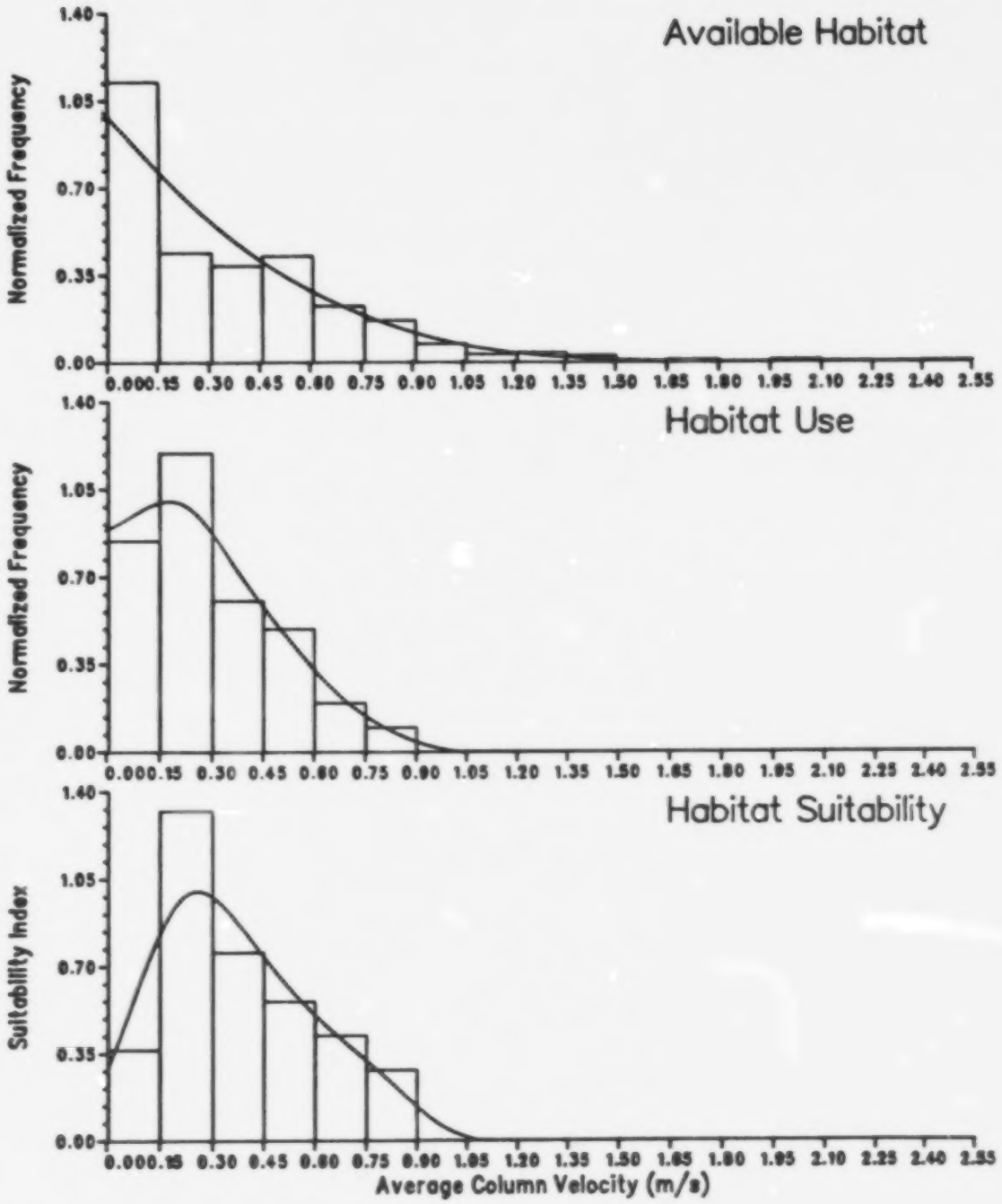


FIGURE 26 Available average water column velocities, velocity utilization and column velocity preference curves for mountain whitefish fry.

10 = bedrock (Table 3). During development of the substrate preference curve, the original analysis resulted in an indication that mountain whitefish fry exhibited an equally high preference for medium to large gravel and bedrock. While the preference for gravel was considered to be real, the preference for bedrock was evaluated as being a result of the technique being employed in identification of habitat preference. In this instance, very few mountain whitefish fry were observed in areas where the substrate consisted of bedrock; however, bedrock substrate was equally uncommon as a substrate type. Therefore, when habitat utilization was corrected for (i.e., divided by) available habitat, the result was a high preference for bedrock substrates. As this consequence was considered a result of the technique and not an actual habitat preference, the high preference for bedrock was edited out of the curve. The resulting relationship indicates a slight preference for sand and silt substrates, as is found in backwaters, with highest preference being for gravel and cobble substrates (Figure 24). No editing of the apparent depth and velocity preferences of mountain whitefish fry was carried out (Figures 25 and 26).

The habitat preferences of mountain whitefish juveniles during the summer months as determined for the Oldman River are illustrated in Figures 27, 28 and 29. These relationships are based on 141 measurements, and the observation of 375 mountain whitefish juveniles. A situation comparable to that of fry existed in regard to substrate preferences with this life stage, in that very few mountain whitefish juveniles were observed in regions of bedrock substrate, but bedrock substrate was observed to be rare. During the preparation of the substrate preference curve, the indicated moderate preference for bedrock was edited out of the relationship (Figure 27). No editing of the depth (Figure 28) or velocity (Figure 29) preferences of this life stage was carried out.

A total of 133 measurements were carried out to develop the habitat preferences for adult mountain whitefish during the summer season. A total of 249 adults was observed at these measurement points. During the analysis of substrate preferences, the situation with bedrock preference again arose, which was also corrected during the editing process (Figure 30). A biomodal curve resulted from the analysis of depth preferences,

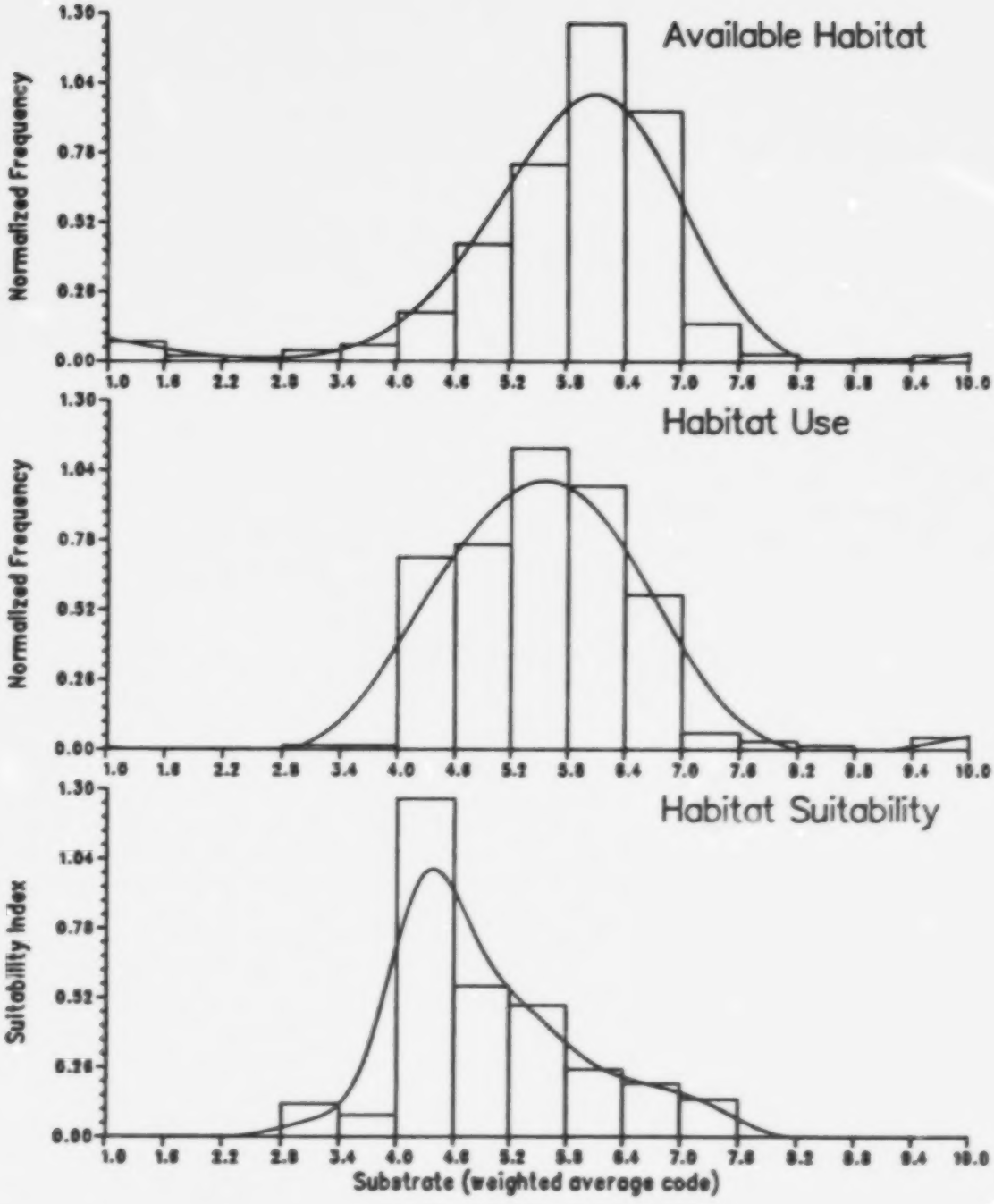


FIGURE 27 Available substrates, substrate utilization and substrate preference curves for mountain whitefish juveniles.

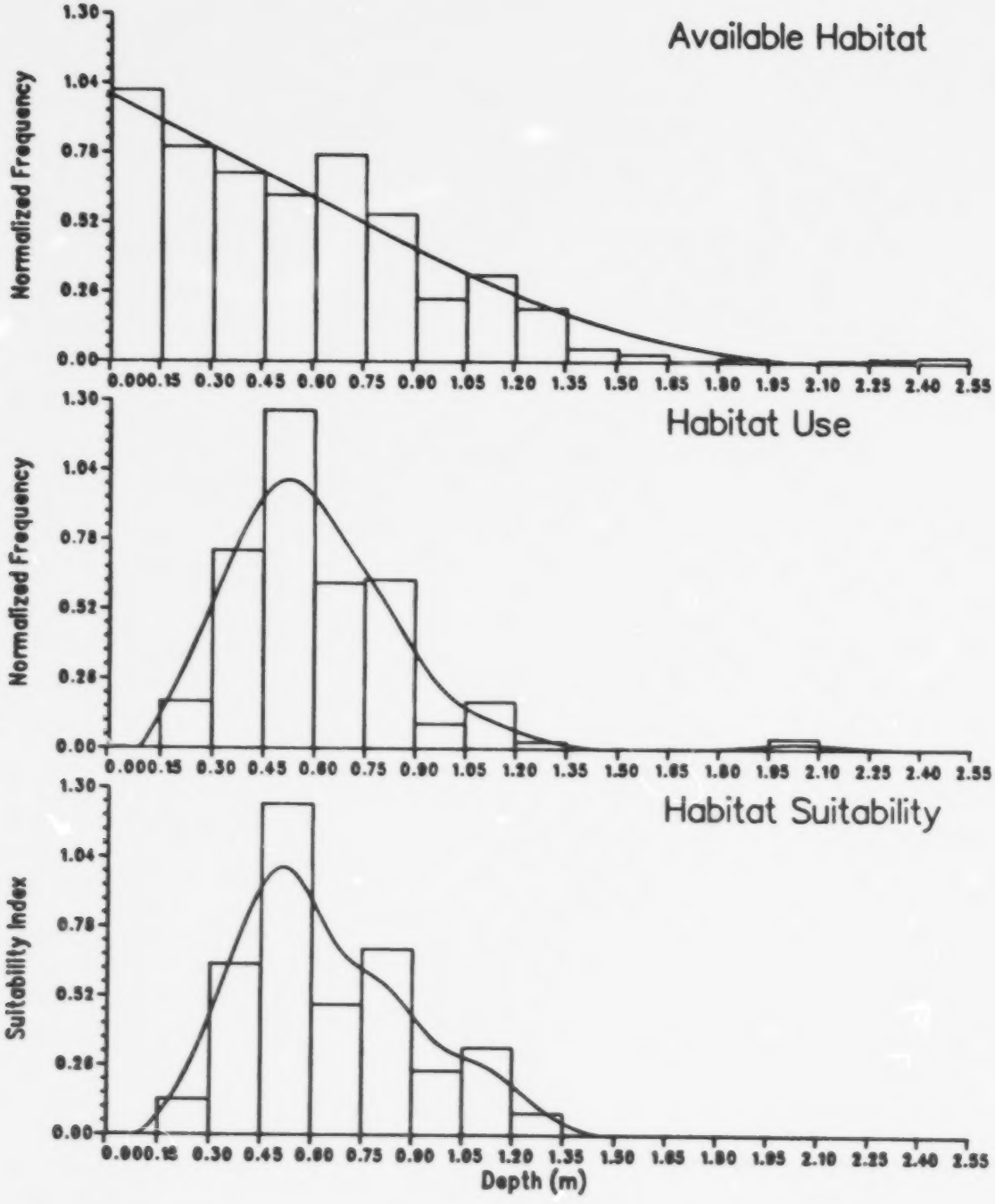


FIGURE 28 Available depths, depth utilization and depth preference curves for mountain whitefish juveniles.

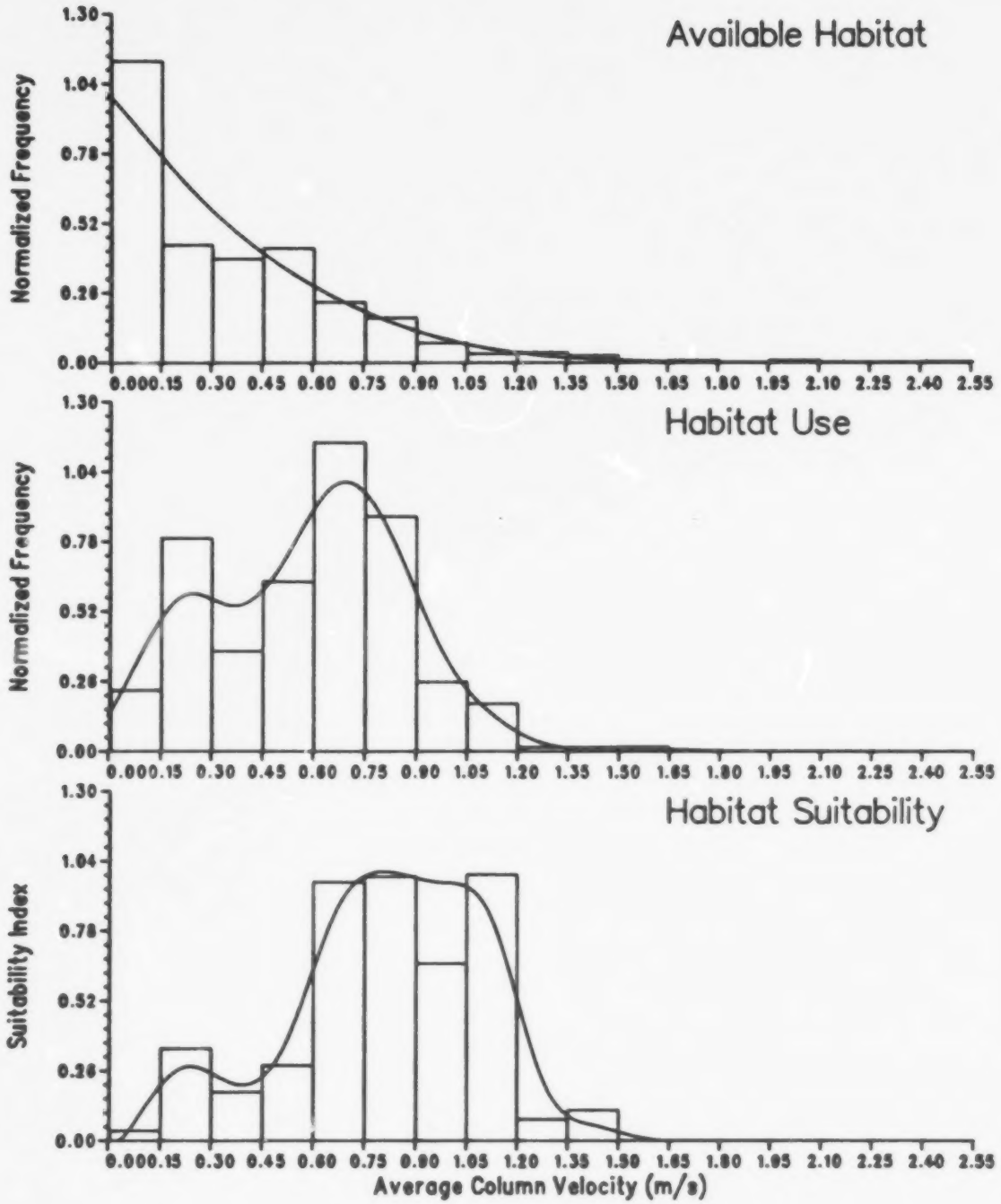


FIGURE 29 Available average water column velocities, velocity utilization and column velocity preference curves for mountain whitefish juveniles.

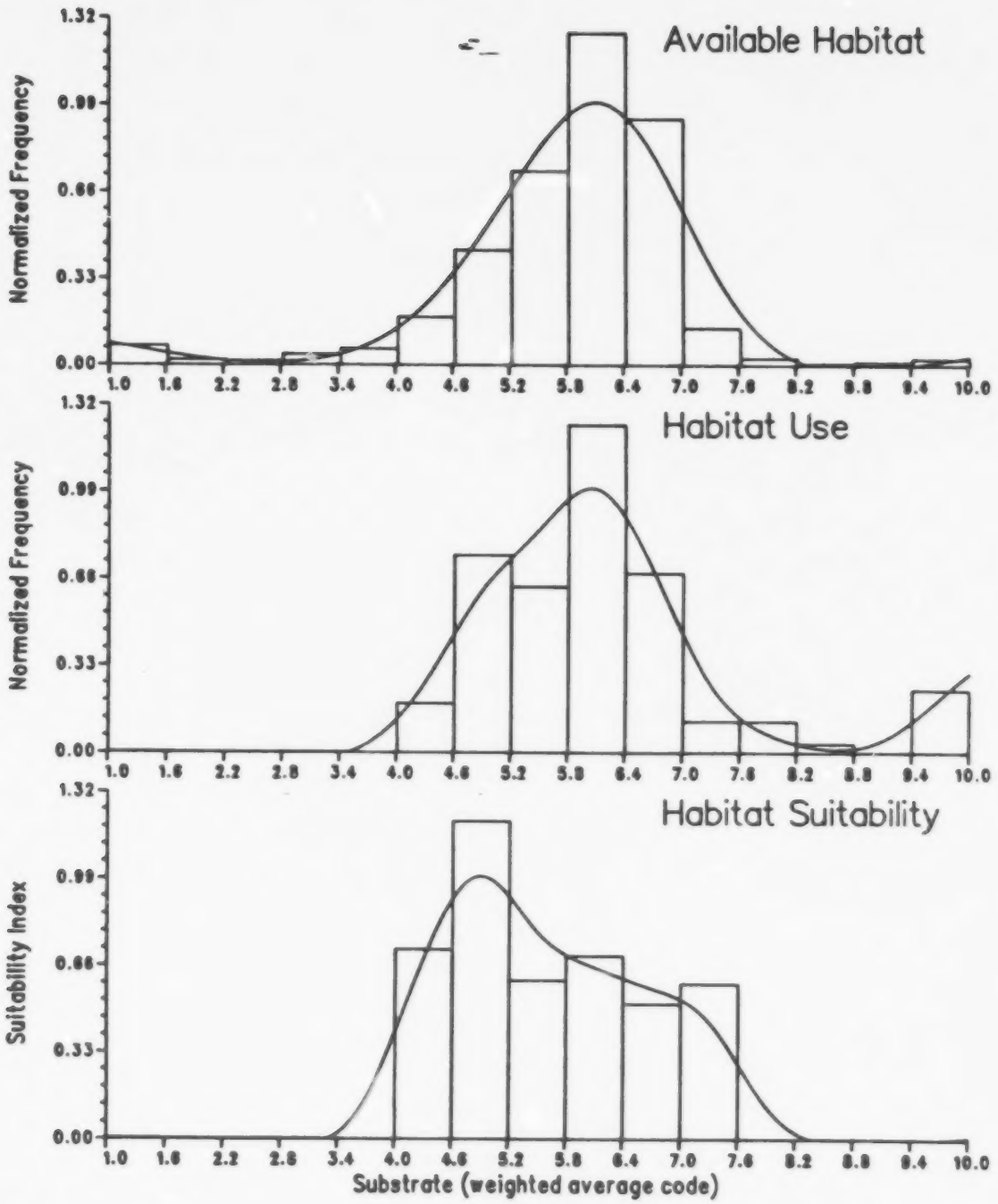


FIGURE 30 Available substrates, substrate utilization and substrate preference curves for adult mountain whitefish.

which is thought to result from differences in daily activities (Figure 31). The shallower preference is likely the result of feeding activities, which often occur in riffles and runs particularly in the morning. The deeper preference is thought to be a result of the habitat type used for holding, which was used in the late morning and afternoon. The adult mountain whitefish habitat preferences for the summer months are illustrated in Figures 30 through 32.

The habitat characteristics preferred by mountain whitefish for spawning are illustrated in Figures 33, 34 and 35. These curves were generated from 107 sampling locations where both spawners (as determined by diver observation or electrofishing) and eggs were present at the same location.

The habitat preference curves developed for juvenile rainbow trout, based on 102 sampling locations, are presented in Figures 36, 37 and 38. In calculating the preferences from habitat utilization information, the available habitats in Segments 4, 5 and 6 only were used, as these juveniles did not inhabit the lower river segments in the study area.

5.2 EXISTING FISHERIES RESOURCE

5.2.1 Seasonal Distribution and Abundance

5.2.1.1 Introduction

The distribution and abundance of each species in the study area was determined through a consideration of all sampling methods, since effectiveness of each sampling technique varied with species and life-history stage. The results of fisheries inventory studies conducted in summer and fall, 1985 are summarized according to sampling method. Detailed catch or observation records for each method are provided in Appendix I.

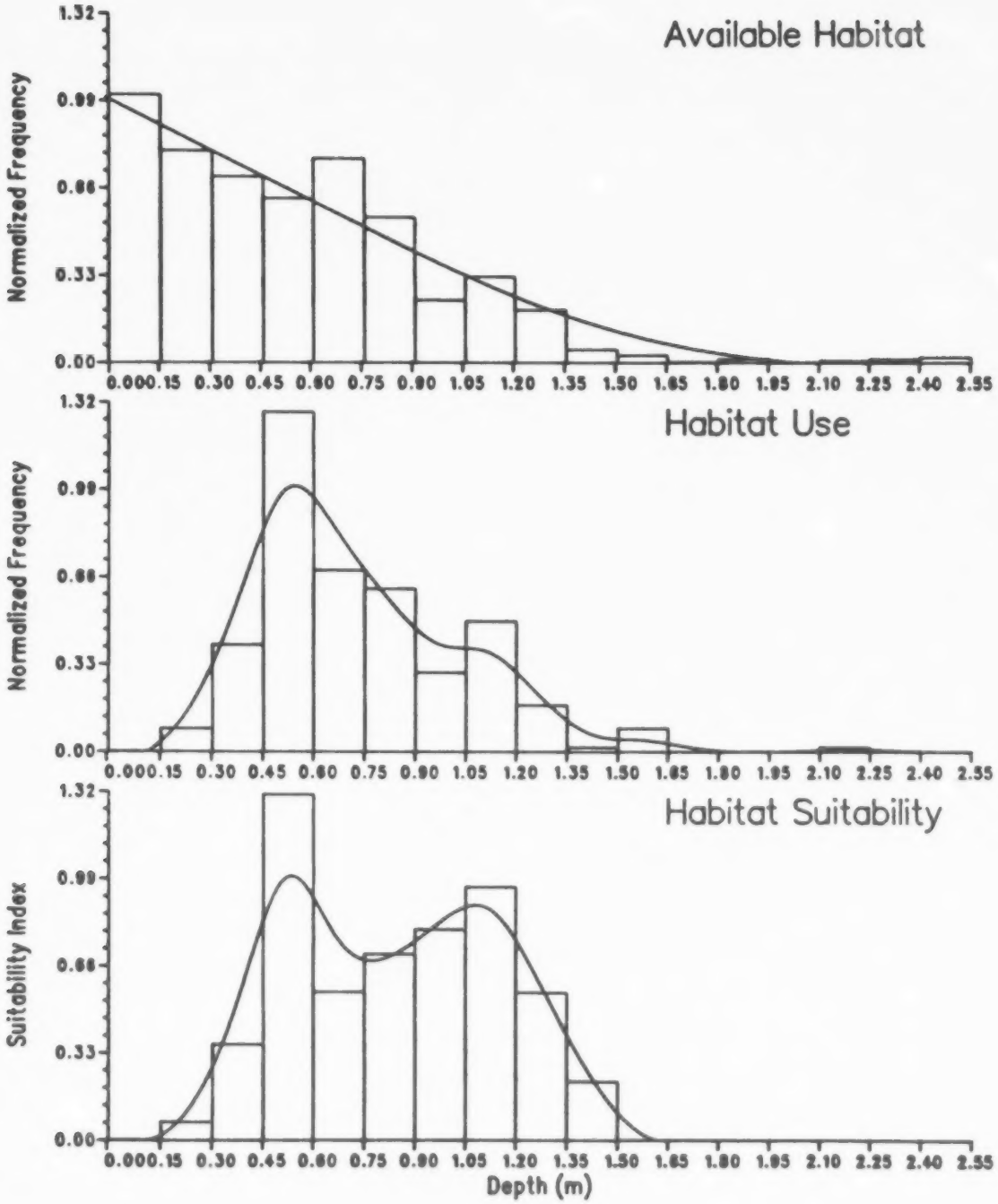


FIGURE 31 Available depths, depth utilization and depth preference curves for mountain whitefish adults.

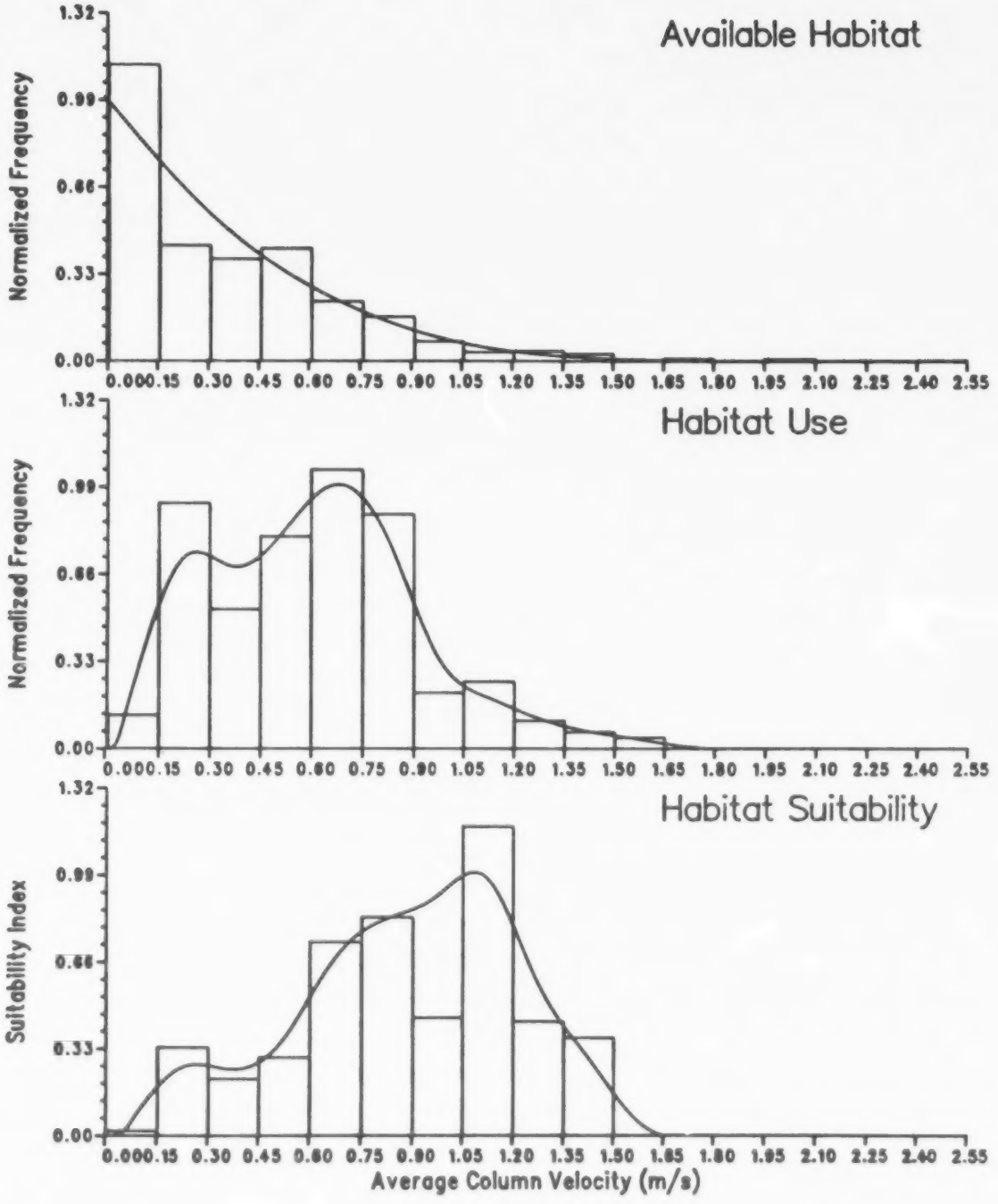


FIGURE 32 Available average water column velocities, velocity utilization and average column velocity preference curves for mountain whitefish adults.

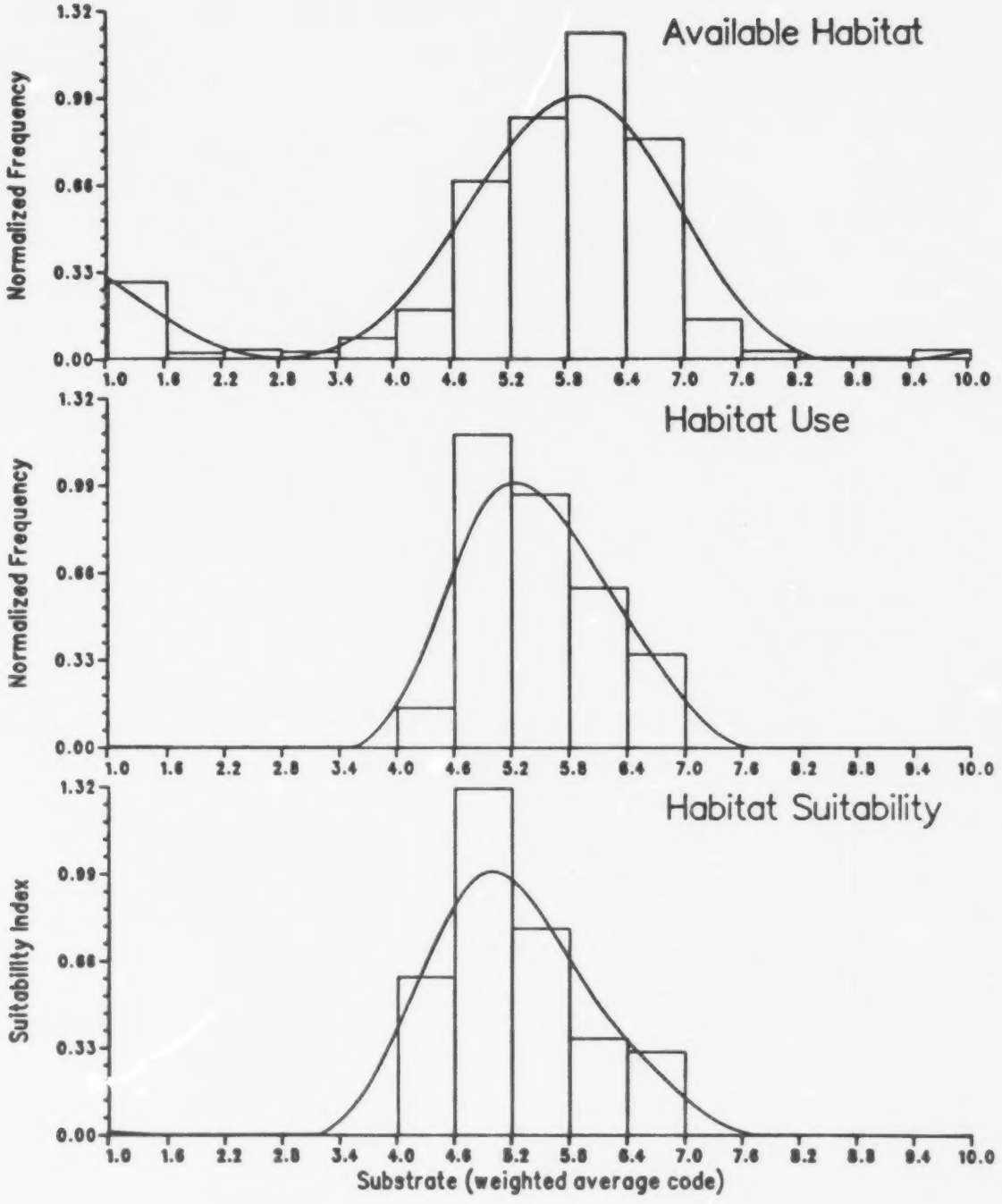


FIGURE 33 Available substrates, substrate utilization and substrate preference curves for mountain whitefish spawning.

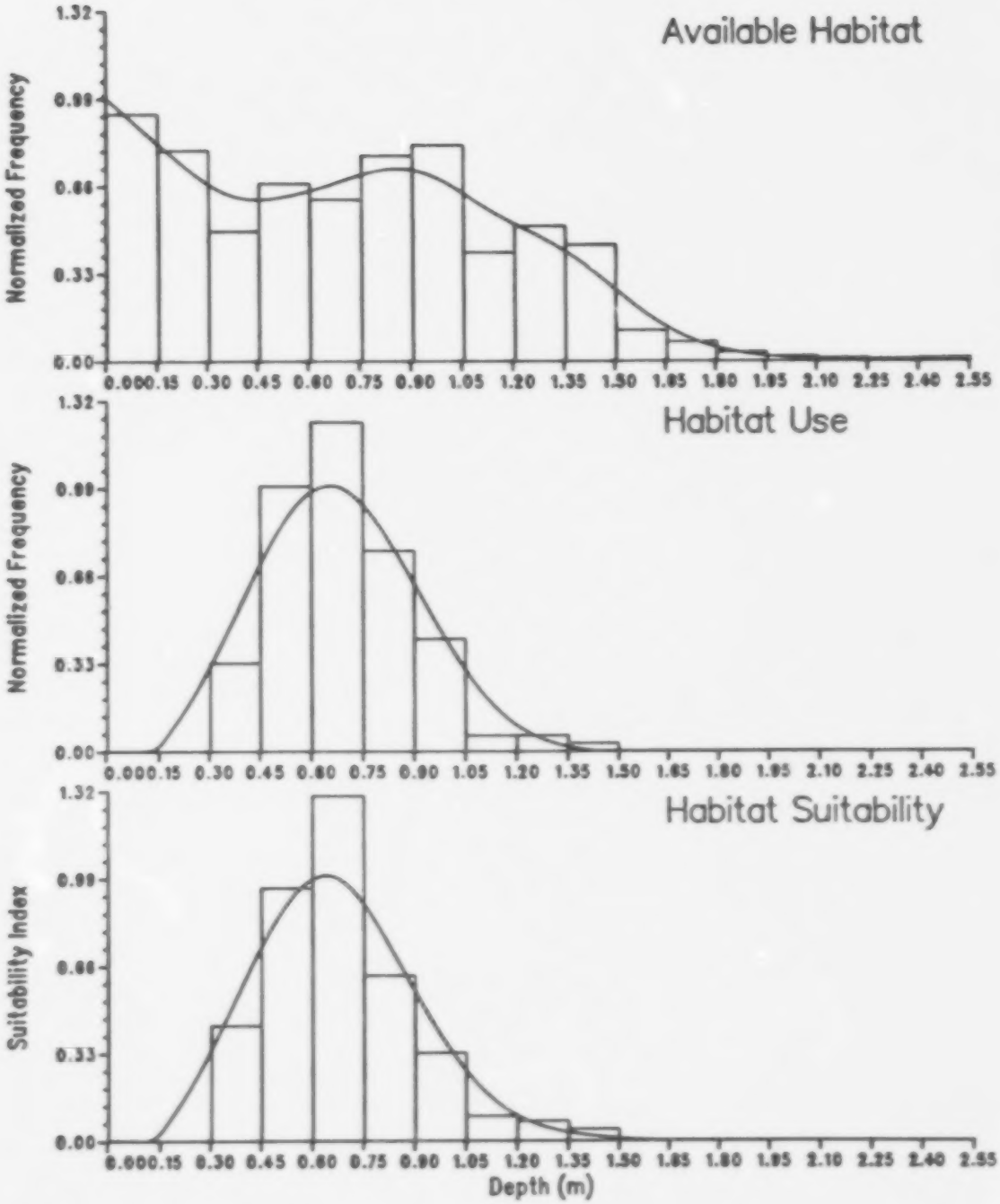


FIGURE 34 Available depths, depth utilization and depth preference curves for mountain whitefish spawning.

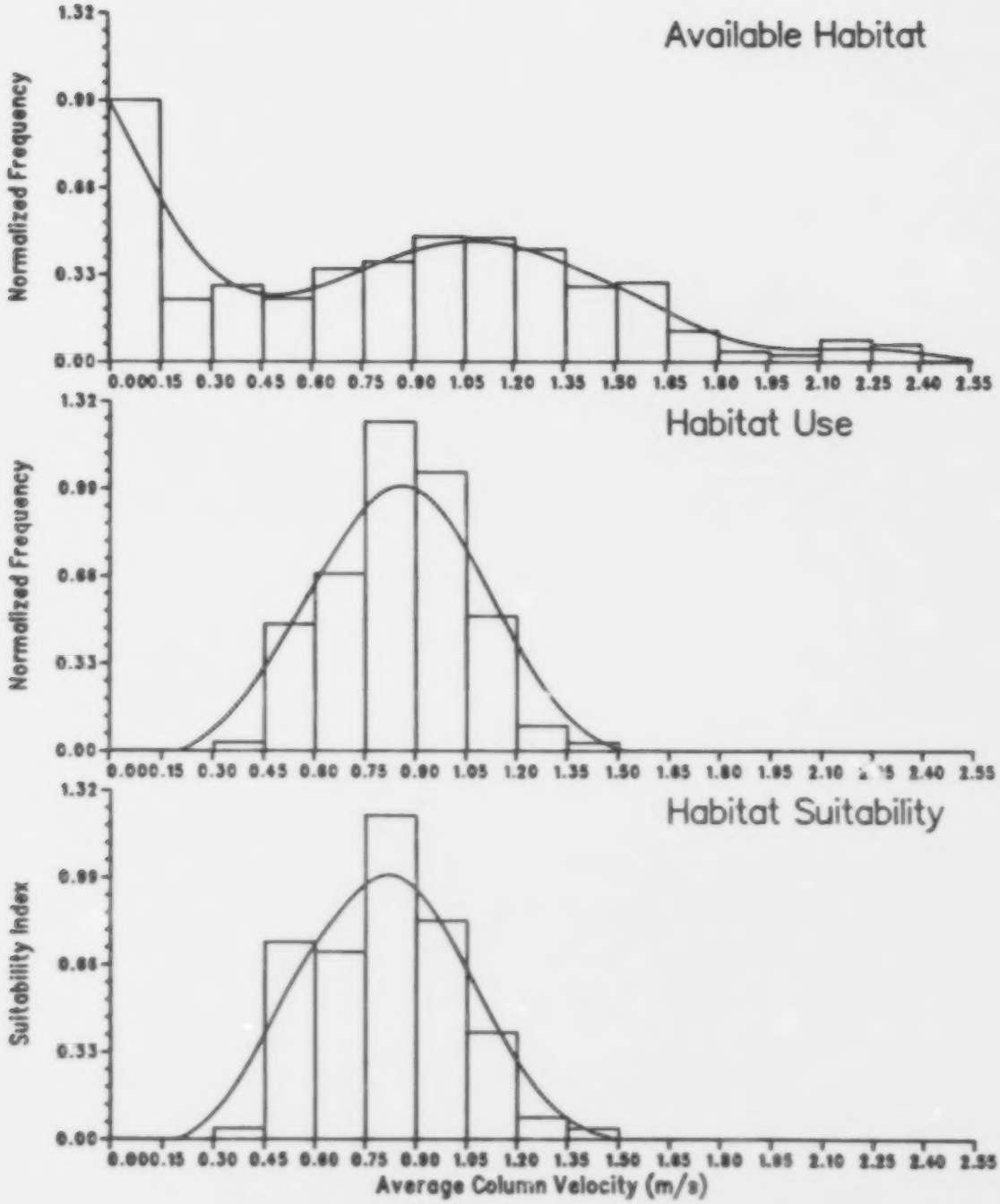


FIGURE 35 Available average water column velocities, velocity utilization and average column velocity preference curves for mountain whitefish spawning.

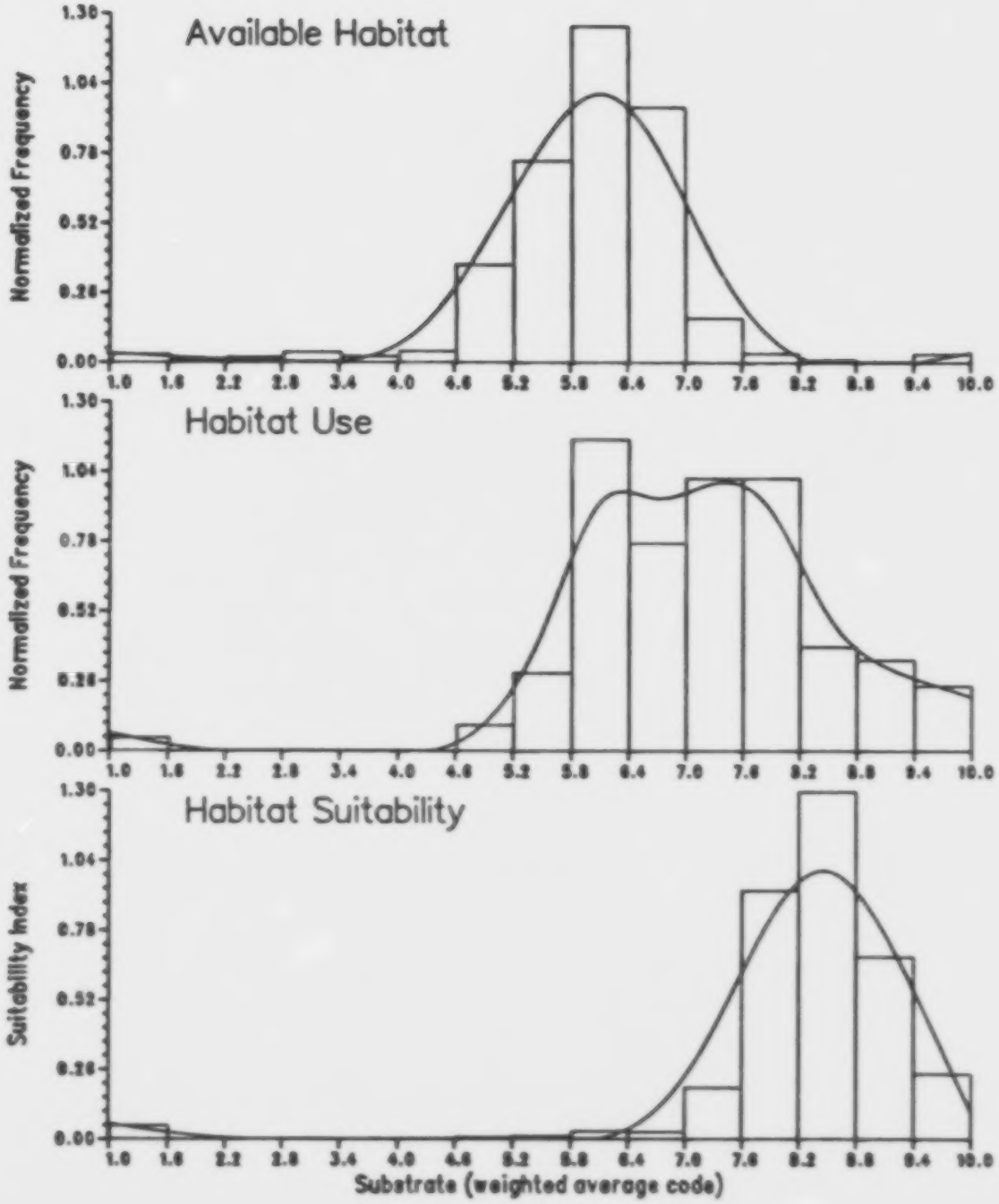


FIGURE 36 Available substrates, substrate utilization and substrate preference curves for rainbow trout juveniles.

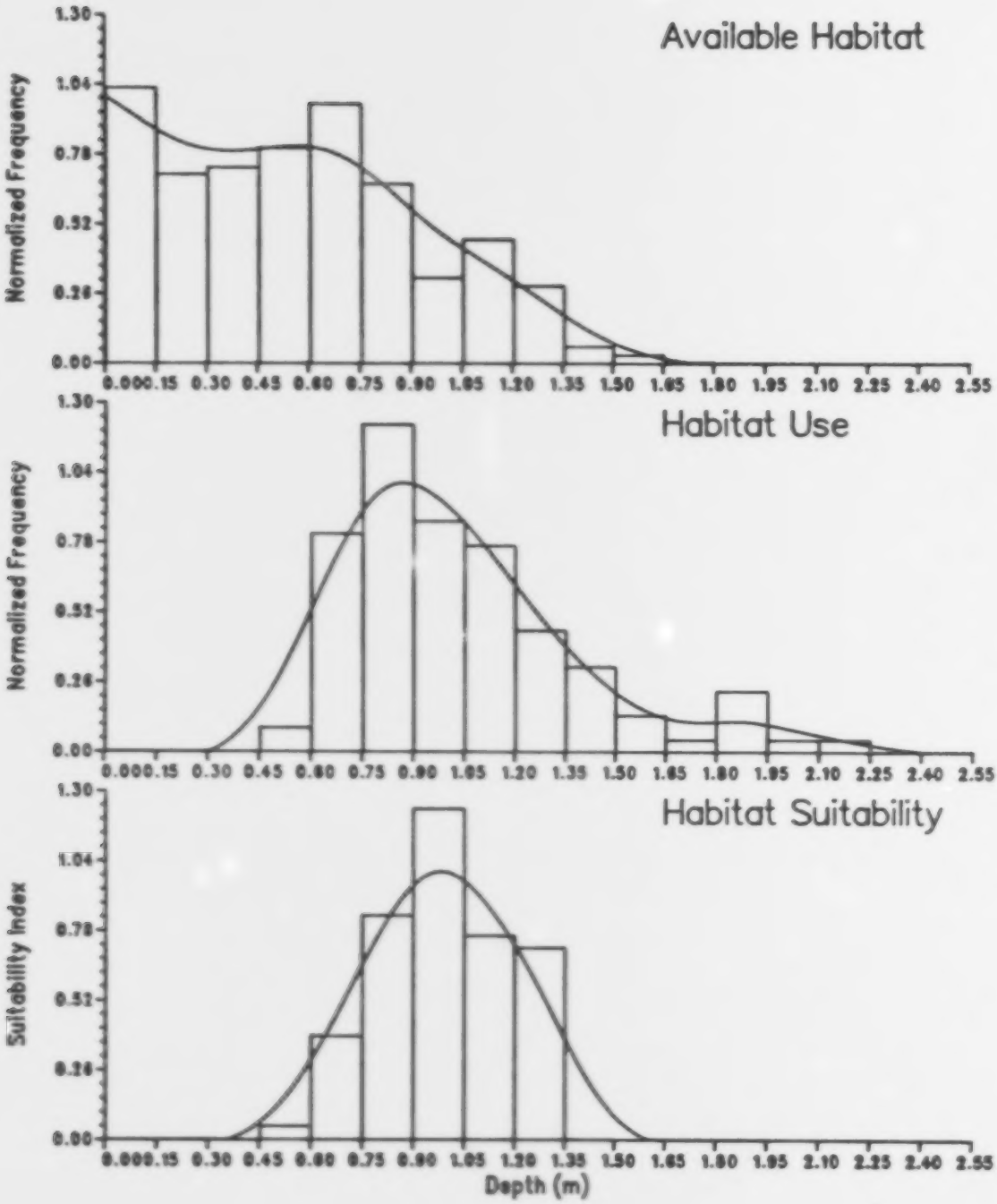


FIGURE 37 Available depths, depth utilization and depth preference curves for rainbow trout juveniles.

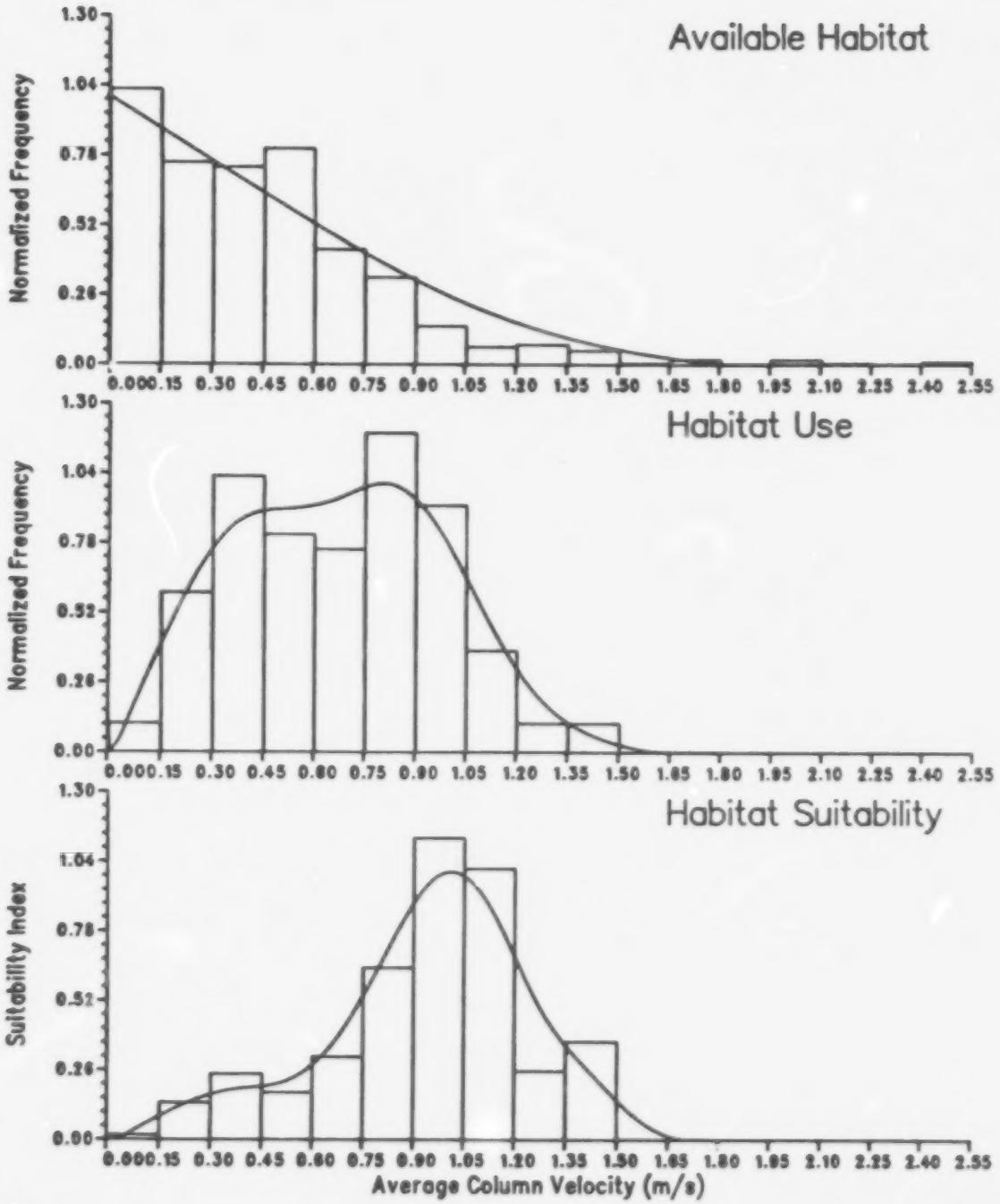


FIGURE 38 Available average water column velocities, velocity utilization and average column velocity preference curves for rainbow trout juveniles.

Tables 7 and 8 are summaries of gill-net sampling results, including CPUE, from the summer and fall of 1985. Direct comparisons of results from summer and fall in each segment are possible since similar mesh sizes were used in the same locations whenever possible. Estimated effort during fall sampling may, in some instances, be greater than actual efforts because nets occasionally became fouled with leaves or debris. Greater CPUE values during the summer for some species (e.g, walleye and sauger) may be due in part to the greater vulnerability of these species in summer when water levels were low and available habitat limited.

Results of boat electrofishing are summarized in Tables 9 and 10. Effort was restricted in summer due to low water levels. Backpack electrofishing was conducted only in summer (Table 11); due to high water levels during the fall other more efficient sampling methods such as boat electrofishing were employed at that time. Seine netting was also restricted almost entirely to summer due to high water levels in fall (Table 12).

Inventory of fishes by diver observation is summarized in Table 13. This table does not include fishes observed while collecting habitat use data for IFIM. Observations are grouped by date to represent the summer (18 July to 6 August), late summer (27 to 28 August) and fall (2 October) time periods, when fish distributions may have differed. A summary of fishes observed from the surface is presented in Table 14. Observations of diurnal movements of mountain whitefish in late August are summarized in Table 15. Note that the counts in Table 15 may include repeated observations of some fish. Effectiveness of direct observation methods depended in part on turbidity of the water, although observations were not done if visibility was poor. Due to differences in activity of fish throughout the day, observation results may also have been affected by time of day when conducted.

The CPUE results from kick sampling for mountain whitefish eggs are presented by segment in Table 16.

TABLE 7

SUMMARY OF GILL NET SAMPLING RESULTS, OLDMAN RIVER, JULY-AUGUST, 1985

Segment	No. Nets Set	Duration (h)	Catch (Total No. of Individuals) Catch per Unit Effort (No. /panel-h)[a]																
			Mountain Whitefish		Lake Whitefish	Rainbow Trout		Northern Pike	Sauger	Walleye	Mooneye	Longnose Sucker	White Sucker		Shorthead Redhorse	TOTAL
			Juv[b]	Ad	Ad	Juv	Ad	Ad	Ad	Ad	Ad	Ad	Juv	Ad	Ad	
1	5	71.81						(7)0.10	(9)0.13	(1)0.01	(2)0.03	(103)1.43		(57)0.79	(2)0.03	(181)2.52
2	4	53.77		(2)0.04				(3)0.06	(1)0.02	(15)0.28		(71)1.32		(10)0.19	(1)0.02	(103)1.92
3	2	27.32		(6)0.22				(3)0.11	(2)0.07	(3)0.11	(1)0.04					(15)0.55
4	4	65.04	(2)0.03	(5)0.08	(2)0.03			(5)0.08				(25)0.38	(5)0.08	(18)0.28	(8)0.12	(70)1.08
5	1	13.12														(0)0.00
6	4	65.21		(4)0.06		(5)0.08	(1)0.02					(6)0.09		(3)0.05		(19)0.29
TOTAL	20	296.27	(2)0.01	(17)0.06	(2)0.01	(5)0.02	(1)0.01	(18)0.06	(12)0.04	(19)0.06	(3)0.01	(205)0.69	(5)0.02	(88)0.30	(11)0.04	(388)1.31

[a] All panels were 15.2 m in length x 2.4 m in depth.

[b] Life History Stages: Juv = Juvenile
Ad = Adult

TABLE 8

SUMMARY OF GILL NET SAMPLING RESULTS, OLDMAN RIVER, OCTOBER, 1985

Segment	No. Nets Set	Duration (h)	Catch (Total No. of Individuals) Catch per Unit Effort (No./panel-h)[a]								
			Mountain Whitefish Ad[b]	Lake Whitefish Ad	Rainbow Trout Juv	Rainbow Trout Ad	Northern Pike Ad	Sauger Ad	Walleye Ad	White Sucker Ad	TOTAL
1	2	28.95					(4)0.14	(1)0.03	(1)0.03		(6) 0.20
2	4	65.62		(1)0.02						(1)0.02	(2) 0.04
3	0	0									(0) 0.00
4	2	27.38									(0) 0.00
5	1	13.87	(1)0.07		(1)0.07	(1)0.07					(3) 0.21
6	3	42.95	(4)0.09		(11)0.26	(4)0.09					(19) 0.44
TOTAL	12	178.77	(5)0.03	(1)0.01	(12)0.07	(5)0.03	(4)0.02	(1)0.01	(1)0.01	(1)0.01	(30) 0.19

[a] All panels were 15.2 m in length x 2.4 m in depth.

[b] Life History Stage: Juv = Juvenile
Ad = Adult

TABLE 9

SUMMARY OF BOAT ELECTROFISHING RESULTS, OLDMAN RIVER, JULY, 1985

Segment	Total Sampling Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)												
		Mountain Whitefish			Rainbow Trout		Northern Pike	Sauger	Walleye	Mooneye	Longnose Sucker		White Sucker	
		Fa	Juv	Ad	Juv	Ad	Ad	Ad	Ad	Ad	Juv	Ad	Juv	Ad
1	965								(1)0.10					
2	0													
3	1493			(1)0.07			(1)0.07	(1)0.07	(4)0.27	(1)0.07			(3)0.20	(16)1.07
4	351													(12)3.42
5	901	(3)0.33	(18)2.00	(12)1.33	(1)0.11	(1)0.11					(5)0.55	(14)1.55		(14)1.55
6	601	(1)0.17	(50)8.32	(40)6.66	(1)0.17							(24)4.00		(20)3.33
TOTAL		(4)0.10	(68)1.58	(53)1.23	(2)0.05	(1)0.02	(1)0.02	(1)0.02	(5)0.12	(1)0.02	(5)0.12	(38)0.88	(3)0.07	(62)1.44

continued . . .

Table 9 (concluded)

Segment	Total Sampling Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s) Shorthead Redhorse Ad	Mountain Sucker Ad	Unidentified Sucker Juv	Longnose Dace Ad	Trout-perch Ad	Emerald Shiner Ad	Spottail Shiner Ad	TOTAL
1	965					(100)10.37	(100)10.37	(100)10.37	(301)31.20
2	0								(0) 0.00
3	1493	(1)0.07							(28) 1.88
4	351		(4)1.14	(50)14.25		(1) 0.28		(12) 3.42	(79)22.51
5	901		(5)0.55		(55)6.10				(128)14.21
6	601		(50)8.32					(1) 0.17	(187)31.11
TOTAL		(1)0.02	(59)1.37	(50) 1.16	(55)1.28	(101) 2.34	(100) 2.32	(113) 2.62	(723)16.77

[a] Life History Stages: F = Fry
Juv = Juvenile
Ad = Adult

TABLE 10

SUMMARY OF BOAT ELECTROFISHING RESULTS, OLDMAN RIVER, OCTOBER, 1985

Catch
(Total No. of Individuals) Catch per Unit Effort (No./100s)

Segment	Sampling Effort (s)	Mountain Whitefish F[a]	Mountain Whitefish Juv	Mountain Whitefish Ad	Lake Whitefish Ad	Rainbow Trout Juv	Rainbow Trout Ad	Brown Trout Juv	Cutthroat Trout Juv	Bull Trout Juv	Northern Pike Ad
1	2010										
2	3561	(2)0.06	(23) 0.65	(11) 0.31							(2)0.06
3	0										
4	11427	(14)0.12	(400) 3.50	(353) 3.09		(7)0.06	(10)0.09	(1)0.01		(1)0.01	(1)0.01
5	6096	(7)0.11	(1616)26.51	(2728)44.75		(4)0.07	(6)0.10		(1)0.02		(1)0.02
6	5737	(6)0.10	(114) 1.99	(348) 6.07	(3)0.05	(5)0.09	(4)0.07				
TOTAL	28831	(29)0.10	(2153) 7.47	(3440)11.93	(3)0.01	(16)0.06	(20)0.07	(1)0.01	(1)0.01	(1)0.01	(4)0.01

continued . . .

Table 10 (continued)

Segment	Total Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)									
		Burbot Ad	Longnose Sucker Juv	Longnose Sucker Ad	F	White Sucker Juv	White Sucker Ad	Shorthead Redhorse Ad	Mountain Sucker Juv	Mountain Sucker Ad	Unidentified Sucker Ad
1	2010			(4)0.20		(2)0.10	(5)0.25				
2	3561			(20)0.56		(1)0.03	(8)0.22	(1)0.03			(16)0.45
3	0										
4	11427			(81)0.71	(2)0.02		(40)0.35		(2)0.02	(2)0.02	(26)0.23
5	6096	(6)0.10	(1)0.02	(171)2.81			(35)0.57				
6	5737	(7)0.12		(92)1.60			(18)0.31				
TOTAL	28831	(13)0.05	(1)0.01	(368)1.28	(2)0.01	(3)0.01	(106)0.37	(1)0.01	(2)0.01	(2)0.01	(42)0.15

continued . . .

Table 10 (concluded)

Segment	Total Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s) Longnose Dace Juv	Longnose Dace Ad	Pearl Dace Ad	Trout-perch Ad	Emerald Shiner Juv	Emerald Shiner Ad	TOTAL
1	2010	(12)0.60			(1)0.05	(24)1.19	(1)0.05	(49) 2.44
2	3561							(84) 2.36
3	0							(0) 0.00
4	11427							(940) 8.23
5	6096		(3)0.05	(1)0.02				(4580)75.13
6	5737		(3)0.05					(600)10.46
TOTAL	28831	(12)0.04	(6)0.02	(1)0.01	(1)0.01	(24)0.08	(1)0.01	(6253)21.69

[a] Life History Stages: F = Fry
Juv = Juvenile
Ad = Adult

TABLE 11

SUMMARY OF BACKPACK ELECTROFISHING RESULTS, OLDMAN RIVER, JULY-AUGUST, 1985

Catch
(Total No. of Individuals) Catch per Unit Effort (No./100s)

Segment	Total Sampling Effort (s)	Mountain Whitefish F[a]	Mountain Whitefish Juv	Mountain Whitefish Ad	Sauger Ad	Burbot Juv	Burbot Ad	Longnose Sucker Juv	Longnose Sucker Ad	White Sucker F	White Sucker Juv	White Sucker Ad
1	2586		(10)0.39	(28) 1.08	(1) 0.04	(2) 0.08	(2) 0.08	(6) 0.23	(77) 2.98		(2) 0.08	
2	329		(1)0.30	(83)25.22					(85) 25.84			(10) 3.04
3	0											
4	1953	(4) 0.20										
5	1913									(7) 0.37		
6	2024											
TOTAL	8805	(4) 0.05	(11)0.12	(111) 1.26	(1) 0.01	(2) 0.02	(2) 0.02	(6) 0.07	(162) 1.84	(7) 0.08	(2) 0.02	(10) 0.11

continued . . .

Table 11 (concluded)

Segment	Total Sampling Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)										
		Shorthead Redhorse	Mountain Sucker		Longnose Dace			Trout-perch	Emerald Shiner	Spottail Shiner	Flathead Chub	
		Ad	Juv	Ad	F	Juv	Ad	Ad	Ad	Ad	Ad	TOTAL
1	2586	(66) 2.55		(217) 8.40		(360) 13.92	(2155) 83.33		(1) 0.04	(1) 0.04	(1) 0.04	(2929)113.26
2	329	(5) 1.52										(184) 55.93
3	0											(0) 0.00
4	1953		(9) 0.46		(1) 0.05		(258) 13.21	(56) 2.87				(328) 16.79
5	1913		(5) 0.26	(20) 1.05			(245) 12.81	(127) 6.64				(404) 21.12
6	2024			(52) 2.57			(350) 17.30	(19) 0.94		(1) 0.05		(422) 20.85
TOTAL	8805	(71) 0.81	(14) 0.16	(289) 3.28	(1) 0.01	(360) 4.09	(3008) 34.16	(202) 2.29	(1) 0.01	(2) 0.02	(1) 0.01	(4267) 48.46

[a] Life History: F = Fry
Juv = Juvenile
Ad = Adult

TABLE 12

SUMMARY OF SEINE NET SAMPLING RESULTS, OLDMAN RIVER, 1985

Catch
(Total No. of Individuals) Catch per Unit Effort (No./100 m^2)

Segment	Sampling Effort[a] Area Seined (m^2)	Mountain Whitefish F[b]	Mountain Whitefish Juv	Mountain Whitefish Ad	Northern Pike Ad	Longnose Sucker F	Longnose Sucker Juv	Longnose Sucker Ad	White Sucker F	White Sucker Juv	White Sucker Ad	Shorthead Redhorse F	Shorthead Redhorse Juv	Shorthead Redhorse Ad
Jul-Aug														
1	497				(1)0.20	(693)139.43	(1)0.20		(825)166.00	(62)12.47		(4)0.80		
2	491	(1)0.20	(4)0.81	(7)1.42		(1) 0.20			(33) 6.72	(10) 2.04				
3	665	(1)0.15					(3)0.45		(39) 5.86	(40) 6.02			(7)1.05	
4	1905	(18)0.94	(60)3.15	(33)1.73			(13)0.68	(1)0.05	(4) 0.21	(141) 7.40	(1)0.05			(6)0.32
5	1259	(3)0.23				(21) 1.67	(13)1.03		(96) 7.63	(87) 6.91				
6	2907						(1)0.03				(2)0.07			
TOTAL	7724	(23)0.30	(64)0.83	(40)0.52	(1)0.01	(715) 9.26	(31)0.40	(1)0.01	(997) 12.91	(340) 4.40	(3)0.04	(4)0.05	(7)0.09	(6)0.08
October														
2	710[c]								(1) 0.14					

continued . . .

Table 12 (continued)

Segment	Sampling Effort[a] Area Seined (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100 m^2)											
		Mountain Sucker		Quillback	Unidentified Sucker		Longnose Dace			Trout-perch		Emerald Shiner	
		F	Juv	F	F	Juv	F	Juv	Ad	Juv	Ad	Ad	
Jul-Aug													
1	497			(3)0.60			(13)2.62	(168)33.80	(202) 40.64	(12)2.41	(22) 4.43	(19) 3.82	
2	491	(1)0.30	(3)0.61					(108)22.001	(542) 10.39	(22)4.48	(2) 0.41	(2) 0.41	
3	665	(1)0.15	(27)4.06					(87)13.081	(861)129.47	(11)1.65	(223)33.53	(89)13.38	
4	1905	(5)0.26			(22)1.15	(83)4.36		(7) 0.37	(206) 10.81		(10) 0.52	(38) 1.99	
5	1259		(1)0.08			(1)0.08		(5) 0.40	(45) 3.58	(6)0.48	(66) 5.24		
6	2907		(4)0.14					(1) 0.03	(73) 2.51				
TOTAL	7724	(7)0.10	(35)0.45	(3)0.04	(22)0.28	(84)1.09	(13)0.17	(376) 4.87	(1929) 24.97	(51)0.66	(323) 4.18	(148) 1.92	
October													
2	710[c]										(2) 0.28		

continued . . .

Table 12 (concluded)

Segment	Sampling Effort[a] Area Seined (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100m^2)								
		Spottail Shiner			River Shiner		Lake Chub			
		F	Juv	Ad	Juv	Ad	F	Juv	Ad	TOTAL
Jul-Aug										
1	497	(8)1.61	(16) 3.22	(36)7.24	(9)1.81	(62)12.47	(2)0.40	(3)0.60	(5)1.01	(2166)435.81
2	491		(50)10.18	(20)4.07						(806)164.16
3	665			(56)8.42					(4)0.60	(1449)217.89
4	1905			(26)1.36	(11)0.58	(2) 0.11				(687) 36.06
5	1259		(1) 0.08						(6)0.48	(351) 27.88
6	2907									(81) 2.78
TOTAL	7724	(8)0.10	(67) 0.87	(138)1.78	(20)0.26	(64) 0.83	(2) 0.03	(3)0.04	(15)0.20	(5540) 71.72
October										
2	710[c]									(3) 0.42

[a] Combined Results of Sampling with three seine nets: minnow seine (6.2 m x 1.1 m - 0.8 cm mesh) - total sampling effort 4558 m^2
river seine (14.8 m x 3.0 m - 1.4 cm mesh) - total sampling effort 946 m^2
large mesh seine (15.0 m x 2.0 m - 8.9 cm mesh) - total sampling effort 2220 m^2

[b] Life History Stage - F = Fry; Juv = Juvenile; Ad = Adult

[c] Minnow Seine only - 7.6 m x 1.2 m - 1.1 cm mesh

TABLE 13

SUMMARY OF FISH OBSERVED WHILE FLOATING IN THE OLDMAN RIVER STUDY AREA, 1985[a]

Catch
(Total No. of Individuals) Catch per Unit Effort (No./100m)

Segment	Sampling Period	Total Sampling Effort (m)	Mountain Whitefish F[b]	Mountain Whitefish Juv	Mountain Whitefish Ad	Rainbow Trout Juv	Rainbow Trout Ad	Burbot Ad	Longnose Sucker Ad	White Sucker Juv	White Sucker Ad	Shorthead Redhorse Ad
2	Jul18-Aug06	1500	(2) 0.13	(61) 4.07	(20) 1.33				(10)0.67			(2)0.13
3	Jul18-Aug06	500	(26) 5.20	(1) 0.20								
4	Jul18-Aug06	2400	(539)22.46	(113) 4.71	(3) 0.13							
	Aug27,28	1000		(200)20.00	(200)20.00							(1)0.10
5	Jul18-Aug06	2500	(20) 0.80	(60) 2.40	(25) 1.00	(3)0.12			(13)0.52		(9)0.36	
6	Jul18-Aug06	13600	(94) 0.69	(705) 5.18	(536) 3.94	(42)0.31	(3)0.02		(417)3.07	(1)0.01	(102)0.75	(2)0.01
	Aug27,28	4300	(22) 0.51	(337) 7.84	(341) 7.93	(23)0.53		(2)0.05	(69)1.60		(12)0.28	
	Oct 02	4300			(1) 0.02		(1)0.02		(37)0.86		(2)0.05	
TOTALS	Jul18-Aug06	20500	(681) 3.32	(940) 4.59	(584) 2.85	(45)0.22	(3)0.01		(440)2.15	(1)0.01	(111)0.54	(4)0.02
	Aug27,28	5300	(22) 0.42	(537)10.13	(541)10.21	(23)0.43		(2)0.04	(69)1.30		(12)0.23	(1)0.02
	Oct 2	4300			(1) 0.02		(1)0.02		(37)0.86		(2)0.05	

continued . . .

Table 13 (concluded)

Segment	Sampling Period	Total Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100m)							
			Mountain Sucker			Longnose Dace	Emerald Shiner	Spottail Shiner	Lake Chub	
			F	Juv	Ad	Ad	Ad	Ad	Ad	TOTAL
2	Jul18-Aug06	1500								
				(80)5.33	(120)8.00	(700)46.67				(995)66.33
3	Jul18-Aug06	500								(27) 5.40
4	Jul18-Aug06	2400								
	Aug27,28	1000								(655)27.29
										(401)40.10
5	Jul18-Aug06	2500								(130) 5.20
6	Jul18-Aug06	13600								
	Aug27,28	4300	(1)0.01	(84)0.62	(274)2.01	(200) 1.47	(5)0.04	(10)0.07	(10)0.07	(2486)18.28
	Oct 02	4300		(2)0.05						(808)18.79
										(41) 0.95
TOTALS	Jul18-Aug06	20500								
	Aug27,28	5300	(1)0.01	(164)0.80	(394)1.92	(900) 4.39	(5)0.02	(10)0.05	(10)0.05	(4293)20.94
	Oct 2	4300		(2)0.04						(1209)22.81
	Oct 2	4300								(41) 0.95

[a] Fish observed while collecting habitat use data are not included.
[b] Life History Stages: F = Fry; Juv = Juvenile; Ad = Adult.

TABLE 14

SUMMARY OF FISH OBSERVED FROM THE SURFACE IN THE OLDMAN RIVER STUDY AREA, JULY, 1985

Catch
(Total No. of Individuals) Catch per Unit Effort (No. /100m)

Study Segment	Total Sampling Effort (m)	Mountain Whitefish F[a]	Mountain Whitefish Juv	Mountain Whitefish Ad	Longnose Sucker Ad	White Sucker Juv	White Sucker Ad	Shorthead Redhorse Ad	Mountain Sucker Ad	Emerald Shiner Ad	Spottail Shiner Ad	Lake Chub Ad	TOTAL
2	100		(4) 4.00	(9) 9.00									(13) 13.00
3	925	(19) 2.05	(35) 3.79	(8) 0.86	(6) 0.65	(3) 0.32	(3) 0.32	(3) 0.32	(30) 3.24	(50) 5.41	(30) 3.24	(200) 21.62	(387) 41.84
4	1 500	(145) 9.67	(100) 6.67				(12) 0.80						(257) 17.13
TOTAL	2 525	(164) 6.49	(139) 5.50	(17) 0.67	(6) 0.24	(3) 0.12	(15) 0.60	(3) 0.12	(30) 1.19	(50) 1.98	(30) 1.19	(200) 7.92	(657) 26.02

[a] Life History Stage: F - Fry
Juv - Juvenile
Ad - Adult

TABLE 15

SUMMARY OF OBSERVATIONS OF DIURNAL MOVEMENTS OF MOUNTAIN WHITEFISH, OLDMAN RIVER, AUGUST 26 & 27, 1985
STUDY SEGMENT 4

Date	Time Period	Duration (h)	Total Number of Individuals Observed			
			Moving Upstream J&A[a]	Moving Downstream J&A	Not Moving	TOTAL
Aug 26	1600-1830	2.50			104	104
Aug 27	0600-1400	6.30[b]	262	1845	35	2142
	1400-2045	6.75	1128	49		1177
TOTAL		15.55	1390	1894	139	3423

[a] Life History Stage: J - Juvenile
A - Adult

[b] Observations were not conducted continuously between 0600 - 1400 hrs.

TABLE 16

SUMMARY OF KICK SAMPLING RESULTS, OLDMAN RIVER, OCTOBER, 1985

Study Segment	Date	No. of Kick Seine Sites	Area Sampled (m^2)	No. Mountain Whitefish Eggs Captured	Catch/Unit Effort (No./m^2)
4	Oct 23	10	37.83	7	0.185
5	Oct 16, 18, 22	18	44.11	118	2.675
6	Oct 17,18	24	91.53	169	1.846
TOTAL		52	173.47	294	1.695

The seasonal distribution and abundance of the important fishes in the study area is presented below by species and life-history stage.

5.2.1.2 Mountain Whitefish

Adult and juvenile mountain whitefish were captured in all segments of the study area during inventory sampling in summer, 1985. Both adults and juveniles were captured as far downstream as the spillpool below the Lethbridge Weir. These individuals were unable to move upstream because of the weir. Low water levels and high temperatures during the summer of 1985 appeared to restrict the amount of suitable habitat available to adult and juvenile mountain whitefish in the study area. There was one reported summerkill of mountain whitefish in Segment 3 during August, 1985. Segments 4, 5 and 6 appear to be most heavily utilized by feeding and rearing mountain whitefish, with conditions becoming less favourable downstream.

Observations of adult and juvenile mountain whitefish diurnal movements in Segment 4 in late August, 1985, revealed similar numbers of fish moving upstream and downstream (Table 15). It did not appear that a distinct migration was occurring although nocturnal movements were not investigated, and local fish moving repeatedly up and downstream may have obscured a general trend of migrants.

No mountain whitefish were found in Segment 1 during fall sampling, although the area immediately below the Lethbridge Weir was not sampled. Mountain whitefish juveniles and adults were present in Segments 2, 4, 5 and 6 in the fall, and although no appropriate sampling was conducted in Segment 3, the species is believed to have been present in that region of the river. As during the summer, mountain whitefish abundance was greater in the upstream segments.

The CPUE results for boat electrofishing during the fall were comparable to those of summer in Segment 6 (Tables 9 and 10), but were much

greater in Segment 5. Numbers of mountain whitefish captured while boat electrofishing (Appendix I, Table 3) or observed while floating (Appendix I, Table 6) in Segment 6 in early October indicate that adult and juvenile mountain whitefish had moved out of the segment. In mid- and late October adult and juvenile mountain whitefish were again present in Segment 6, and appeared to be concentrated in riffle areas (Figure 39). In Segment 5, adult and juvenile mountain whitefish were much more abundant during early October than in summer, especially at the Summerview Bridge (Appendix I, Table 3). In mid-October, aggregations of mountain whitefish were present at the Summerview Bridge and in several areas downstream to the LNID Weir (Figures 39 and 40).

Kick sampling in Segments 4, 5 and 6 during the fall determined that spawning occurred in all areas where adult mountain whitefish were found, with the greatest concentrations of eggs in Segment 5 (Table 16). Segment 6 was also used extensively for spawning, while Segment 4 had much lower utilization. Sites at which eggs were recovered are illustrated in Figure 6.

Tagging returns collected to date by Alberta Environment indicate that a large percentage of adult and juvenile mountain whitefish tagged within 5 km of the proposed damsite in spring, 1985, remained in that vicinity through the summer and fall. Of the 565 adult and juvenile mountain whitefish tagged at the LNID Weir in spring, 1985, 10 returns have been received: 8 of these fish had migrated at least as far upstream as the Summerview Bridge by summer or fall, while a small percentage travelled upstream to the Castle River; the other 2 had migrated downstream from the LNID Weir to the Highway 2 Bridge.

Mountain whitefish fry (young-of-the-year) were captured or observed in all but Segment 1 during summer inventory sampling. Fry were most abundant in Segment 4, with the CPUE for this life stage decreasing with distances upstream and downstream (Tables 11, 12 and 13). Mountain whitefish fry were best censused in summer by observation while floating. During the fall, when discharge was higher, fry were best censused by boat

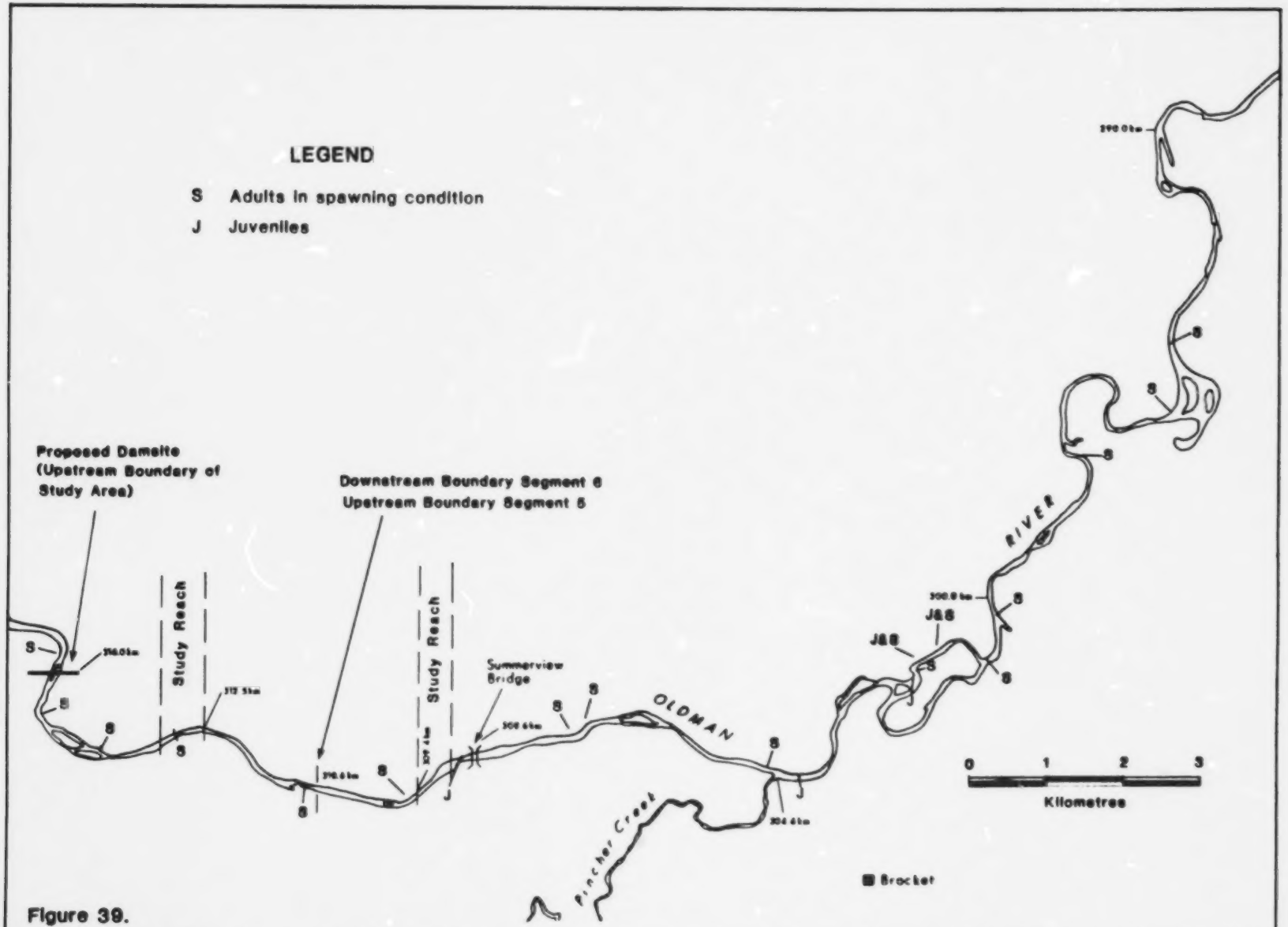


Figure 39.
Locations where adult mountain whitefish in spawning condition or juveniles were located, Segments 5 & 6, October 1985.

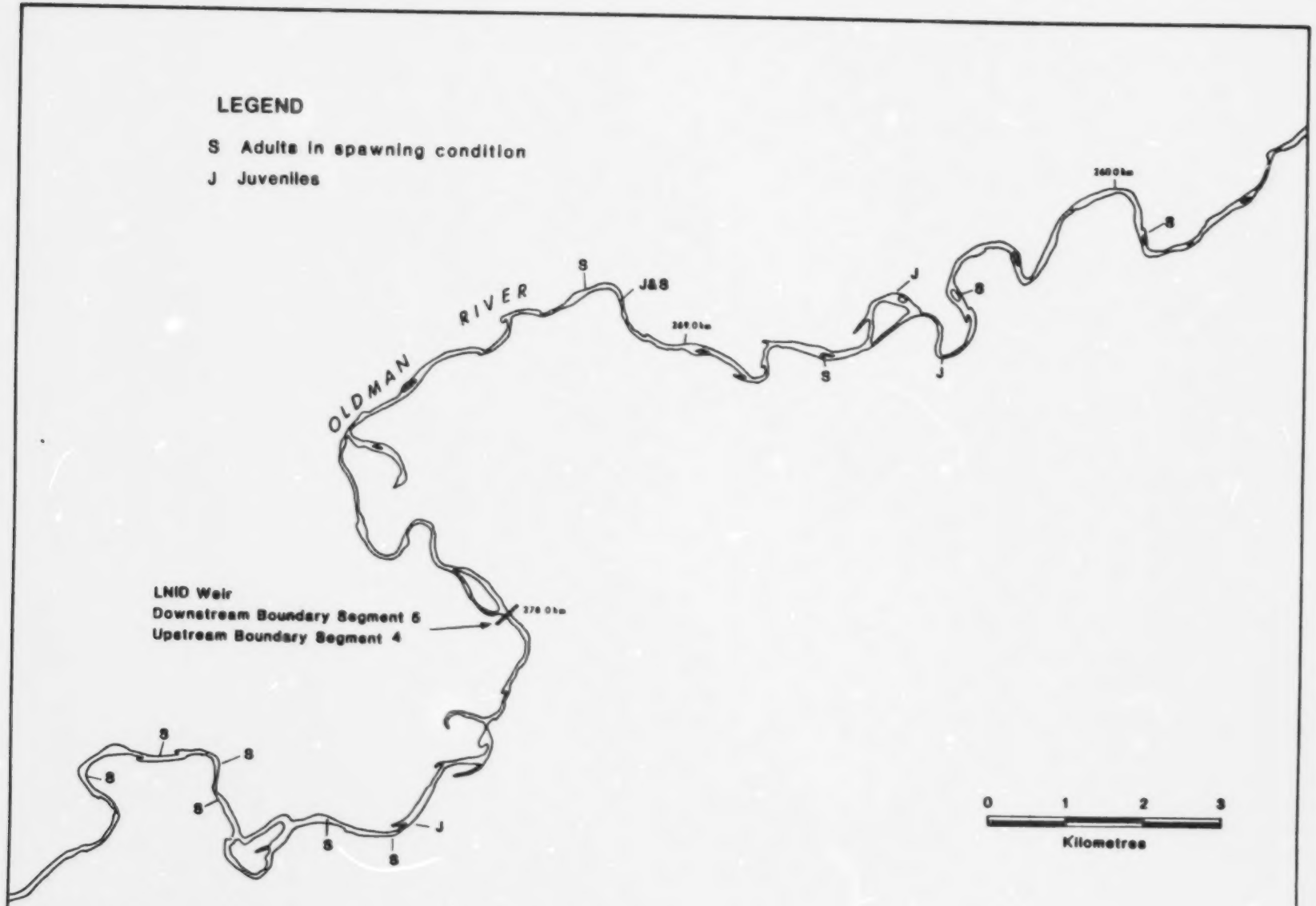


Figure 40.
Locations where adult mountain whitefish in spawning condition or juveniles were located, Segments 4 & 5, October 1985.

electrofishing and were captured at all but Segments 1 and 3 (Table 10). No boat electrofishing was conducted in Segment 3 during the fall but mountain whitefish fry are thought to have been present in this region of the river. Abundance again appears to have been greatest in Segment 4, while CPUE results for Segments 5 and 6 are essentially comparable during the fall.

5.2.1.3 Rainbow Trout

Adult and juvenile rainbow trout were captured only in Segments 5 and 6 during summer inventory sampling. Sampling during the fall resulted in the capture of rainbow trout in Segments 4, 5 and 6. Those fish captured in Segment 4 were all upstream of Highway 2 Bridge, an area which was not sampled during the summer. The CPUE values from summer and fall sampling indicate greater abundance of both adult and juvenile rainbow trout in Segments 5 and 6 than in Segment 4 (Tables 7, 8, 9, 10 and 13). Adults appear to be equally abundant in Segments 5 and 6 while juveniles are more abundant in Segment 6 than in Segment 5. It appears that juvenile rainbow trout are generally more common in upstream areas of their range while adults are more uniformly dispersed. Although electrofishing results do not indicate a change in relative abundance with season (Tables 9 and 10), gill-netting results reveal an increase in the abundance of rainbow trout in the upper region of the study area during the fall (Tables 7 and 8).

No rainbow trout fry were captured or observed in the study area during the sampling program.

5.2.1.4 Other Salmonid Species

A single cutthroat trout was captured in the study area. The individual was a juvenile taken while boat electrofishing in Segment 5 between Summerview Bridge and the LNID Weir. One brown trout and one bull

trout were captured during boat electrofishing in Segment 4 between the LNID Weir and the Highway 2 Bridge. Both fish were juveniles.

Six lake whitefish adults were captured in the study area. Two individuals were captured in gill nets in Segment 4 during summer sampling (Table 7). During fall sampling one individual was captured by gill netting in Segment 2 (Table 8) while three more were captured by boat electrofishing in Segment 6 (Table 10). The fish captured in Segment 4 was a green (not in spawning condition) male, while the three males captured in Segment 6 later in the fall were running ripe (in spawning condition).

5.2.1.5 Northern Pike

Northern pike were captured or observed in Segments 1, 2, 3 and 4 during summer inventory sampling, and in Segments 4 and 5 during collection of habitat use data in summer. During fall sampling northern pike were captured in Segments 1, 2, 4 and 5. A total of 29 individuals were captured or observed; all were adults. Summer gill-net results indicated that northern pike were more abundant in the downstream segments of the study area, especially Segment 1 (Table 7). Fall gill netting resulted in the capture of northern pike only in Segment 1, possibly due to reduced catch efficiency related to high river discharges and increased velocities at gill-net sites in the fall.

5.2.1.6 Walleye and Sauger

Walleye and sauger were captured in Segments 1, 2 and 3 during summer sampling, and in only Segment 1 in the fall. These two species were generally captured in pools. Low capture rates in the fall may have been due to high river discharges and thus a reduced efficiency of sampling gear. All fish captured were adults. Although sample sizes were small (15 sauger and 25 walleye), it appears that sauger were more abundant than walleye in Segment 1 while the converse is true for Segments 2 and 3.

5.2.1.7 Mooneye

Mooneye were captured only in summer, in Segments 1 and 3. A total of 4 adults was captured by boat electrofishing and gill netting. No goldeye were taken during this sampling program in the Oldman River.

5.2.1.8 Burbot

Burbot were observed or captured during summer inventory sampling or collection of habitat use data. The species was most common in Segment 1. Adults were found in Segments 1, 3 ,5 and 6 while juveniles were captured only in Segment 1. During the fall, burbot were captured only in Segments 5 and 6, and in greater abundance than in summer. All were adults which were found in areas where mountain whitefish were congregating.

5.2.1.9 Sucker Species

Longnose sucker were common throughout the study area. Adults were captured or observed in all segments, juveniles in all but Segment 2, and fry in Segments 1, 2 and 5. White sucker were the second most common large sucker species encountered. Representatives of all life-history stages were captured or observed in all river segments. Shorthead redhorse suckers were common but not abundant; adults were observed or captured in all but Segment 5 of the study area. Juvenile shorthead redhorse sucker were captured in Segment 3, and fry in Segment 1. Mountain sucker were found throughout the study area. Adults were captured or observed in all segments, juveniles in all but Segment 1, and fry in Segments 2, 3, 4 and 6. Mountain sucker were very common in Segments 5 and 6 and decreased in abundance with distance downstream.

5.2.1.10 Other Species

Longnose dace were an extremely common species throughout the study area. Juveniles and adults were captured or observed in all segments; fry were found in Segments 1, 5 and 6. Longnose dace were generally found in shallow riffles. Trout-perch were the second most common minnow species present in the study area. Adults were captured in all segments, and juveniles in Segments 1, 2 ,3 and 5. Spottail shiner were also found in all segments of the study area and appeared to have been most abundant in the downstream segments. Emerald shiner were found in all but Segment 5, and also appear to have been most common in the downstream segments of the study area. River shiner were captured only in Segments 1 and 4. They were most abundant in Segment 1. Lake chub were captured in Segments 1, 3, 5 and 6; CPUE values for seining were comparable between segments (Table 12).

One adult flathead chub was captured in Segment 1 at the mouth of the St. Mary's River, and one adult pearl dace was captured in Segment 5. Three quillback fry were seined in Segment 1, at the mouth of the Little Bow River. Spoonhead sculpin were observed occasionally while collecting habitat use data, or captured while kick sampling in Segments 5 and 6.

5.2.2 Life History Characteristics

5.2.2.1 Introduction

The characteristics of several important fish populations within the study area are discussed in the following section of the report. Those species which are addressed are important to the sport fishery of Alberta, and were abundant enough in sampling results to enable analyses of life-history characteristics.

5.2.2.2 Mountain Whitefish

The age-length and age-weight relationships of 125 mountain whitefish are presented in Figure 41. These data are compared to similar information for mountain whitefish from the Sheep River (Thompson 1974) and the Red Deer River (McCart and Jones 1975). Although the aging methods of the studies are not the same, Thompson (1974) compared scale and otolith ages for mountain whitefish and reported that the results of using the two techniques were essentially identical.

It is apparent from these comparisons that Sheep and Oldman River mountain whitefish grow at a comparable rate for the first two years of life, after which the Oldman River population attains a greater length and weight with age. Age-length information only was available for the Red Deer River population; these individuals are considerably shorter at age than either the Sheep or Oldman River mountain whitefish (Figure 41).

The weight-length relationship of mountain whitefish from the Oldman River in 1985 is defined by the equation Log Y (weight)=(-5.92) + 3.41 (Log X), (R^2=0.97). This relationship is based on combined sexes, as the result of comparing the fork lengths and weights of males and females with a student's _t_-test (Sokal and Rohlf 1973) revealed no statistical difference between these parameters (P=0.95). The mountain whitefish weight-length relationship from the Oldman River is compared to that of mountain whitefish from the Sheep River (Thompson 1974) in Figure 42. Oldman River mountain whitefish are slightly heavier than the Sheep River stock until a length of approximately 300 mm, at which time the length-weight relationships are virtually identical.

Some age 2^+ male and female mountain whitefish were sexually mature in the Oldman River study area in 1985 (Figure 43). All males were mature by 3^+ years of age, while all females were sexually mature at age 5^+. The mountain whitefish in the Oldman River mature earlier than those of the Sheep River, as Thompson (1974) found 34 percent and 74 percent of female and male mountain whitefish, respectively, were mature at 3^+ years of age. All males were mature at age 5^+, and all females were mature at 6^+.

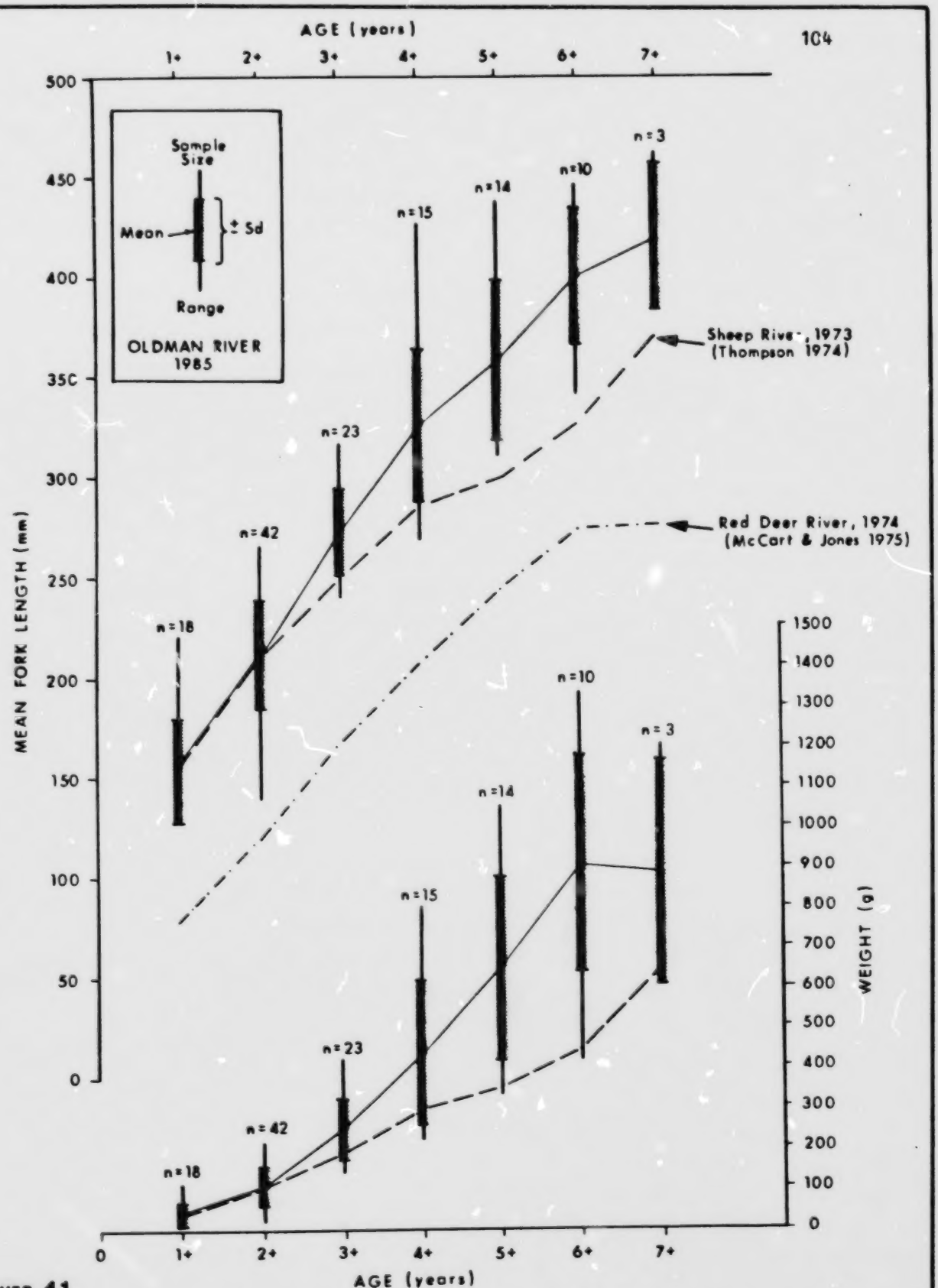


Figure 41.
Comparison of age/length relationships and age/weight relationships of Mountain Whitefish from the Oldman, Sheep and Red Deer Rivers.

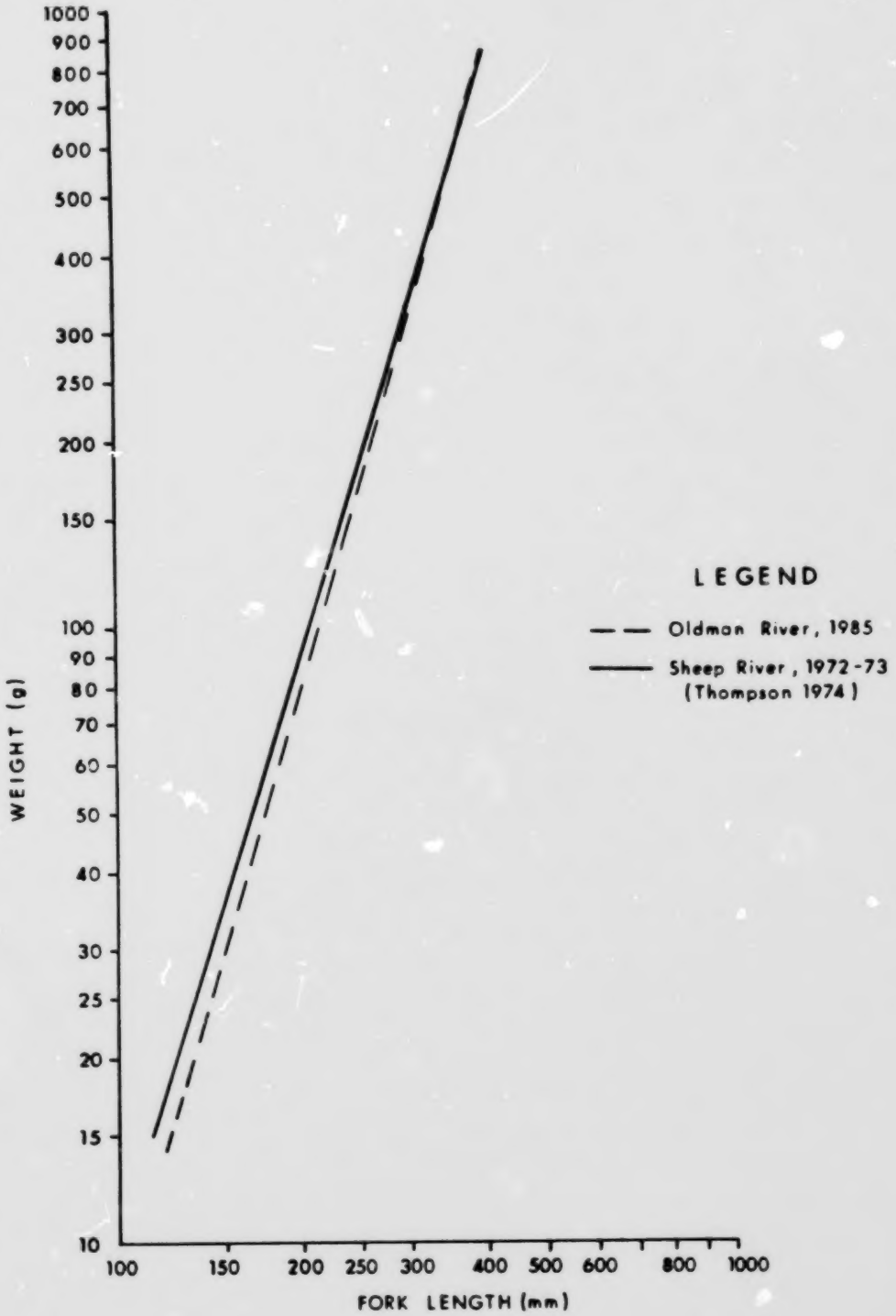


Figure 42. Comparison of weight/ length relationships cf Mountain Whitefish from the Oldman and Sheep Rivers.

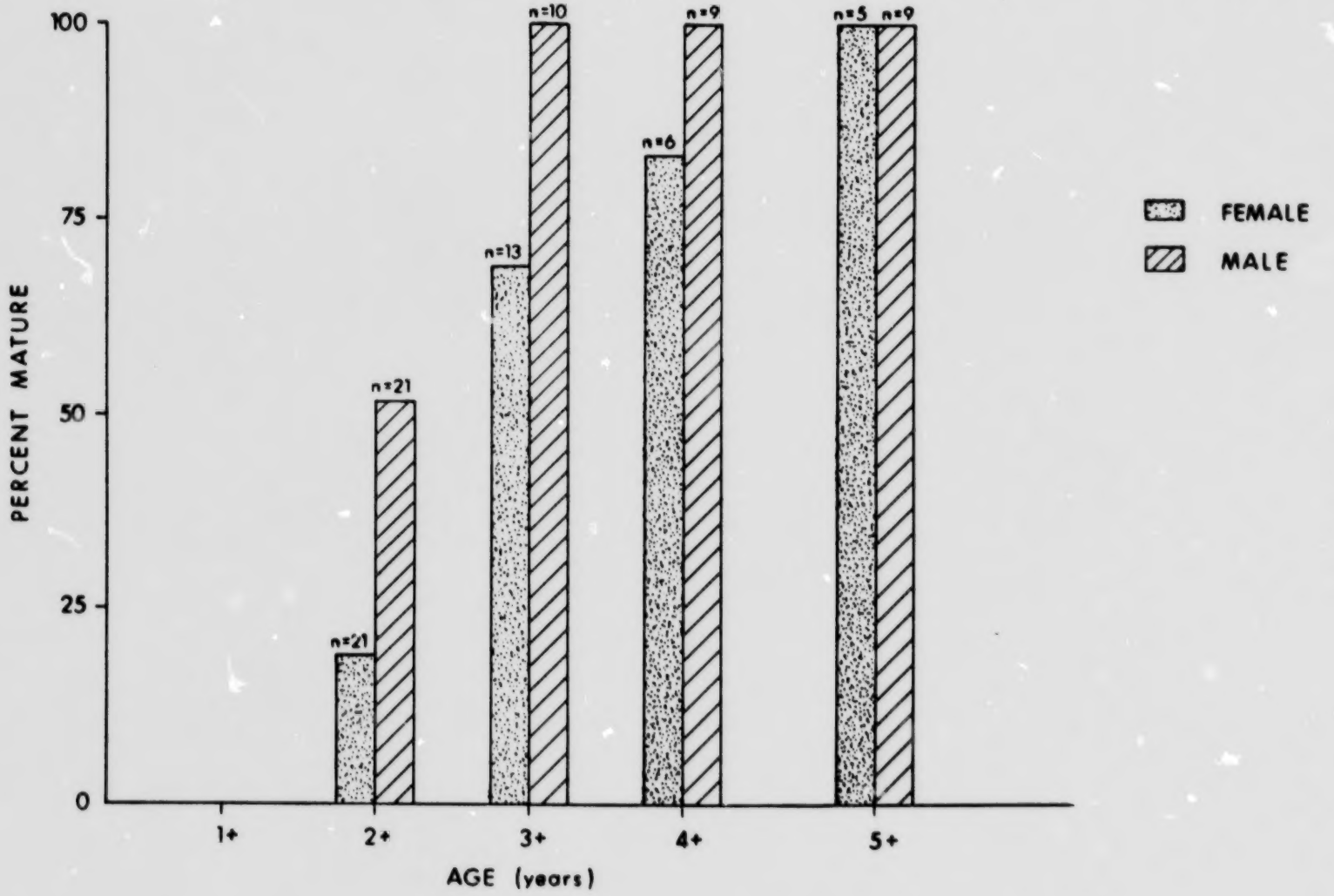


Figure 43. Age of maturity of Mountain Whitefish from from the Oldman River, 1985.

The sex ratio of the Oldman River mountain whitefish populations, based on 312 individuals which were sexed during the study, was 1:1.09 (female:male), or approximately 1:1.

The chronology of spawning activities was determined from the examination of the gonad condition of spawners, and the time at which eggs were first recovered from the river. In 1985, the first running ripe individuals (i.e, gametes easily stripped from fish with only slight pressure on the abdomen) were collected on October 13. Both running ripe males and females were encountered on that date. The first spent (i.e, spawned out) male was recovered on October 14 while the first spent females were taken on October 15, indicating spawning commenced in mid-October. Spawning continued through to October 21, at which time only running ripe males and spent females were taken during sampling. Fish sampling for the study terminated on that date. Mountain whitefish spawning has been reported to occur earlier in the Sheep River, as in 1973 when it commenced on September 29 and continued through to October 18, with the majority of spawning taking place between October 4 and 10 (Thompson 1974).

5.2.2.3 Rainbow Trout

The majority of rainbow trout collected in the study area were juveniles. The age-length and age-weight relationships of 43 individuals are presented in Figure 44. Reliable data are only available for age-classes 1, 2 and 3. In order to put this information into context, they are compared to the growth of rainbow trout in the Bow River, as summarized by Sosiak and Griffiths (1983). It is apparent from these data that juvenile rainbow trout in the Bow River are larger and heavier at age than those of the Oldman River. There is a difference in the aging methods in the two studies, as otoliths were employed in the present investigation while Sosiak and Griffiths (1983) used the scale-aging technique; however, if discrepancies exist between the two techniques, none would be anticipated to occur in juvenile fish.

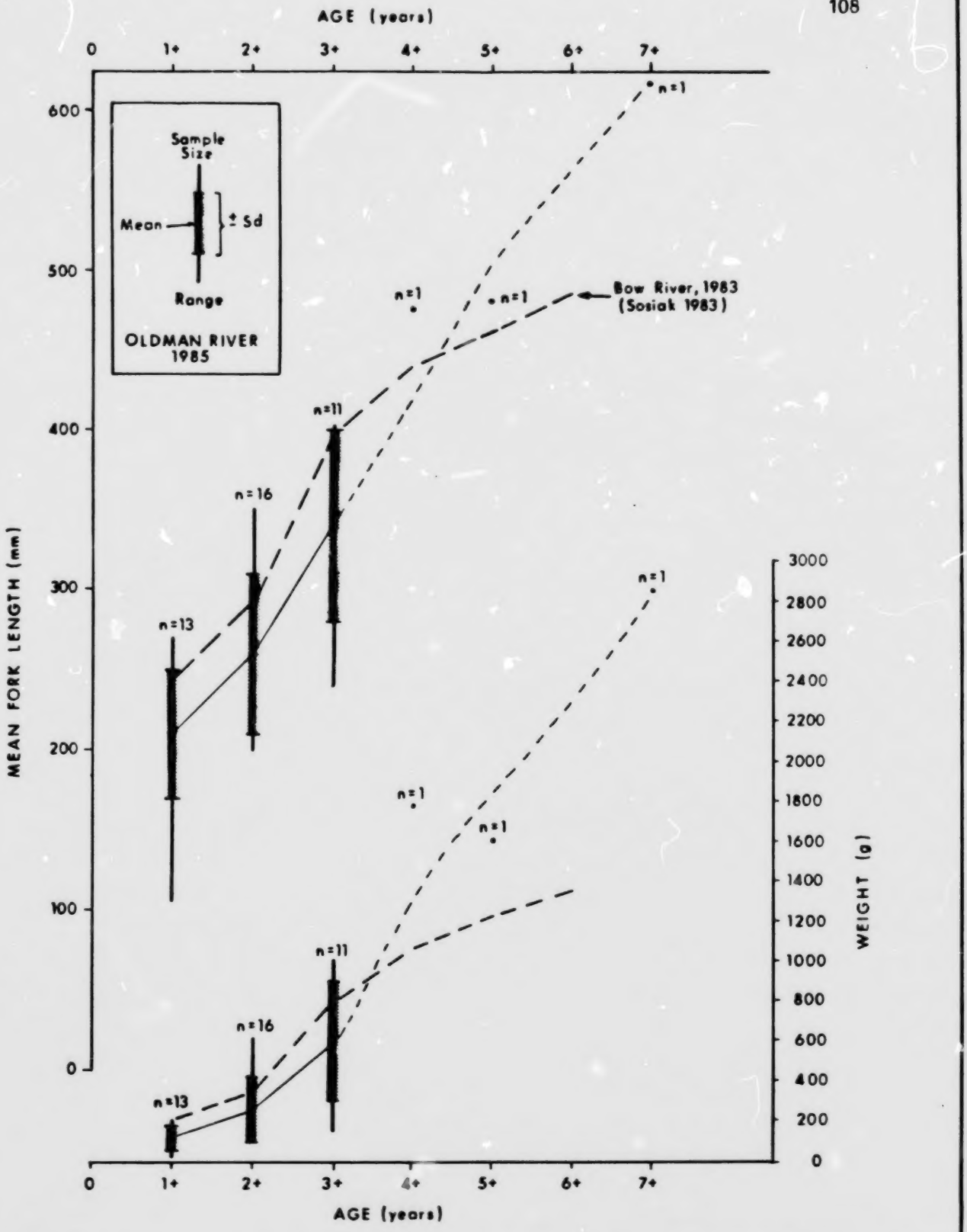


Figure 44. Comparison of age/length relationships and age/weight relationships of Rainbow Trout from the Oldman and Bow Rivers.

The weight-length relationship of 46 rainbow trout from the study area is defined by the equation Log Y (weight)=(-4.03) + 2.65 (Log X), (R^2=0.87). This relationship is plotted in Figure 45, and compared to the weight-length relationships of rainbow trout from the Sheep River (Thompson 1974), Bow River (Sosiak and Griffiths 1983) and Wampus Creek of the McLeod River watershed (Dietz 1971). The weight-length relationships of all these populations are closely grouped, in particular those of the Bow, Sheep and Oldman rivers. Whereas Oldman River rainbow trout are initially slightly heavier than those of the other rivers, the weight-length relationships of the Bow, Highwood and Oldman River rainbow trout are virtually identical between lengths of 250 and 400 mm. All three populations have greater weights at lengths than the Wampus Creek individuals (Figure 45).

As use of the study area in the summer and fall is primarily by juvenile rainbow trout, information on sex ratio and age of maturity is not available. Although sampling was not conducted during the spring spawning period under the present contract, rainbow trout are not anticipated to spawn in the study area (IEC Beak Consultants Ltd. 1985a).

5.2.2.4 Other Species

In general, insufficient data were available to enable an analysis of life history information for the remaining sport-fish species in the study area. The weight-length relationships of two species, walleye and northern pike, are presented in Figures 46 and 47, respectively. These relationships are based on relatively small sample sizes, which precludes any in-depth analyses or comparisons with other populations in the Province. The equations which define these relationships are Log Y (weight)=(-3.90) + 2.64 (Log X), (R^2=0.95) and Log Y (weight)=(-3.74) + (2.52 (Log X), (R^2=0.95) for walleye (n = 19) and northern pike (n = 17), respectively.

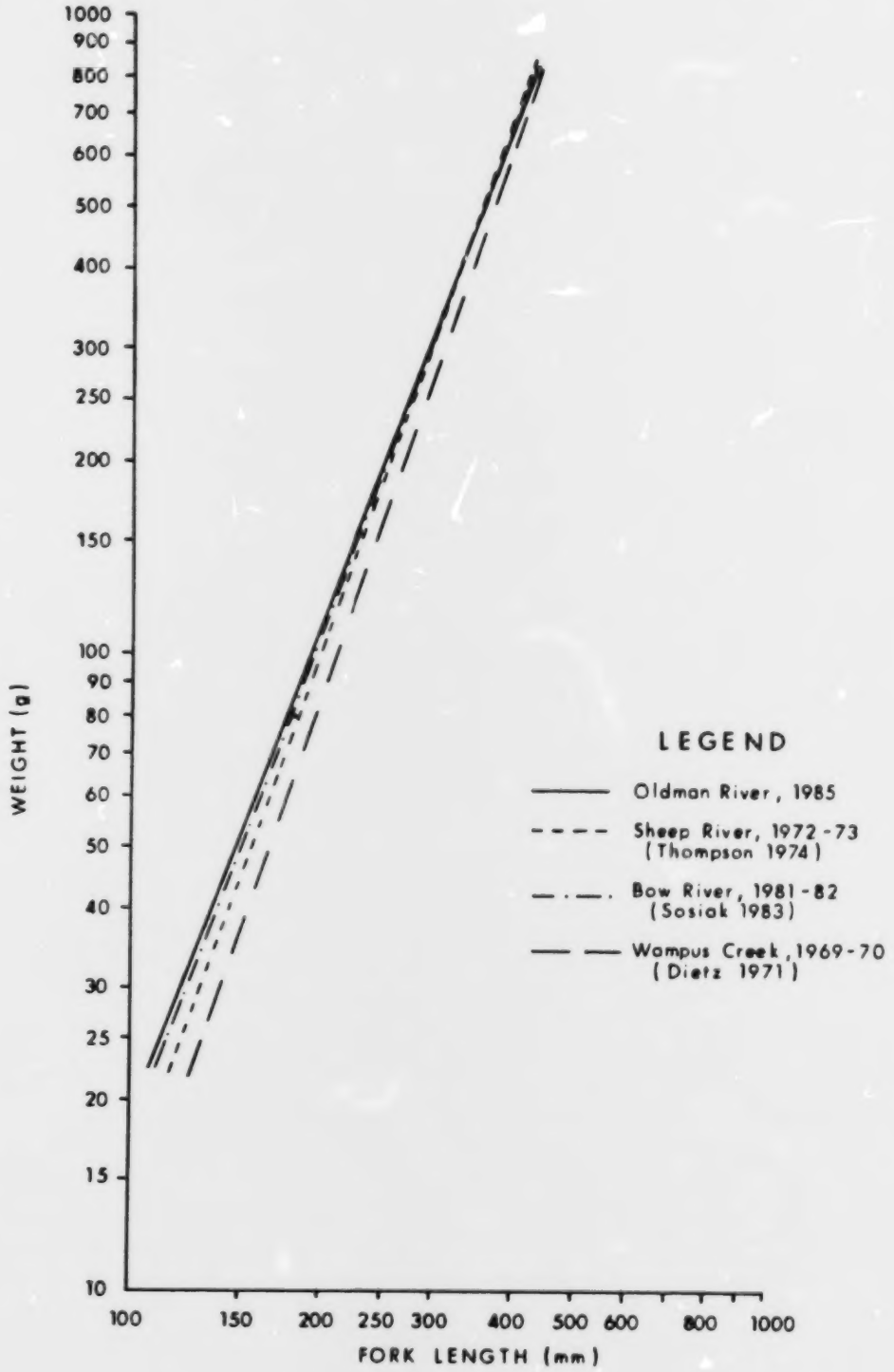


Figure 45. Comparison of weight/length relationships of Rainbow Trout from different areas.

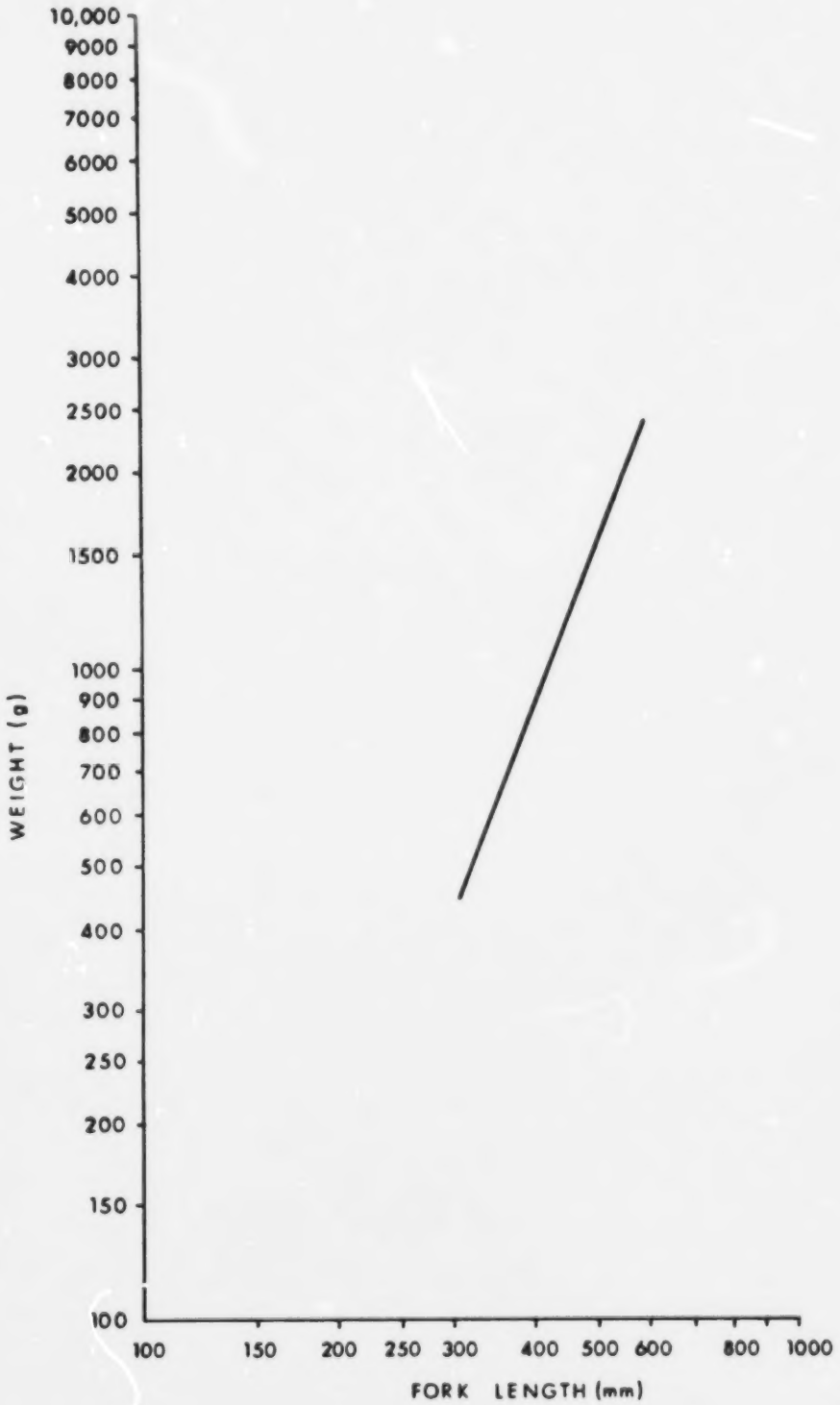


Figure 46. Weight/length relationship of Walleye from the Oldman River, 1985 (n = 19).

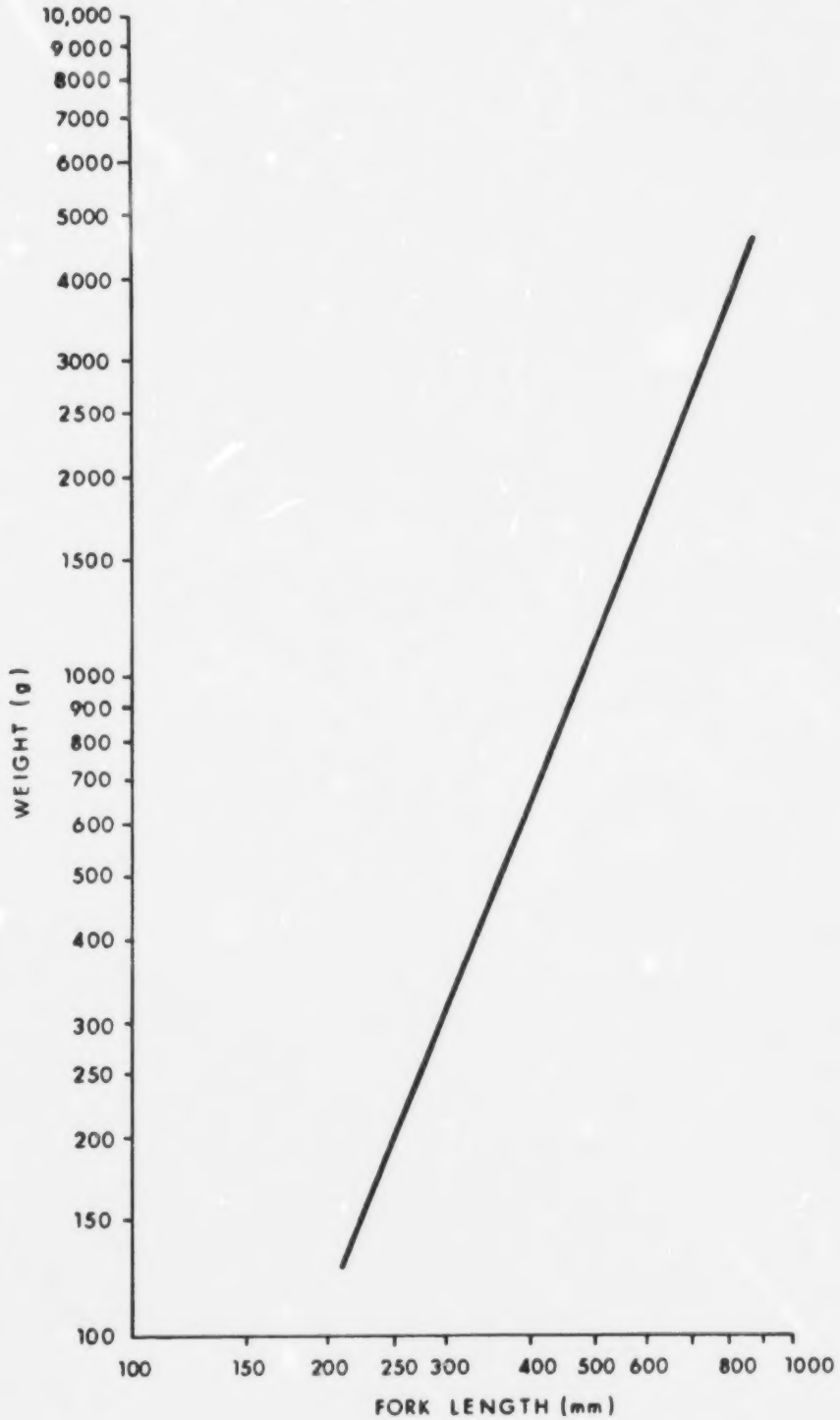


Figure 47. Weight/length relationship of Northern Pike from the Oldman River, 1985 (n = 17).

5.3 WATER QUALITY PREFERENCES FOR FISHES IN THE STUDY AREA

The preferences or tolerated ranges for several water quality characteristics have been extracted from the literature for some of the important fishes in the study area. These data serve to identify the habitat requirements of these species in the region below the damsite, where alterations in these water quality characteristics will be experienced due to the creation of an impoundment. The following discussion includes a brief treatment of the water quality characteristics reviewed (dissolved oxygen, temperature and ammonia), data on ranges and preferred parameter levels where available, and methods that may be employed for evaluating changes in these characteristics on the fish fauna below the impoundment.

5.3.1 Dissolved Oxygen

Oxygen is moderately soluble in water. Natural dissolved oxygen concentrations in surface waters are variable, as they are dependent upon such factors as temperature, turbulence of the water, and atmospheric pressure. Concentrations of dissolved oxygen are also subject to both diurnal and seasonal fluctuations, from factors such as temperature, photosynthetic activity and river discharge. The controls on dissolved oxygen levels are biodepletion and reaeration (McNeely et al. 1979).

The response of fishes to various concentrations of dissolved oxygen is extremely difficult to quantify, largely because i) it is difficult to isolate a single water quality parameter from the remaining array of water quality characteristics which may be influencing the well-being of fishes; and, ii) the natural conditions to which the fishes are exposed appear to play a major role in determining fish productivity at various dissolved oxygen levels. For example, the presence of a diverse fish fauna has been used as the criteria for establishing minimum dissolved oxygen levels (US EPA 1977), which was determined to be 5 mg/l. However, good mixed fish faunas have been documented in warm waters where dissolved oxygen levels do not exceed 4 mg/l for very long periods, are often below 3 mg/l, and sometimes as low as 1.4 mg/l (Doudoroff and Shumway 1970).

No information could be found in the literature regarding preferred oxygen concentrations for mountain whitefish. In his review of oxygen requirements of aquatic life, Davis (1975a, b) cites nine investigations involving rainbow trout. In general, these studies indicate that negative physiological effects occur when the percent saturation of water falls below approximately 50. Davis (loc. cit.) also developed criteria for assessment of harm for various fish groups with emphasis on Canadian species. This evaluation technique is presented in Table 17, for the purpose of evaluating oxygen concentrations which may be expected below the Oldman River Dam when these data are available. The harm (or risk) commitment levels defined by the author are presented on this table.

If the potential exists for gas supersaturation at the dam spillway, the potential for gas bubble disease in fishes should also be evaluated. This affliction occurs when the sum of the individual tensions of dissolved gases, chiefly nitrogen and oxygen, greatly exceeds the hydrostatic pressure, including the pressure of the atmosphere (Weitkamp and Katz 1980). The disease occurs under such conditions where the transport of water raises the water temperature several degrees (such as power plant cooling and sewage treatment), or physically traps air or other gases under pressure (such as dam spillage, sludge and sewage processing) (D'Aoust and Clark 1980), or from intense photosynthetic activity of phytoplankton whereby a considerable amount of oxygen is introduced into the medium without rapid removal of nitrogen (Doudoroff and Shumway 1970). Harvey (1975) reviewed the topic of gas bubble disease in fish and states that there is no known naturally occurring case of gas disease due to oxygen alone. Therefore, concern regarding the disease cannot be addressed without consideration for other gases, notably nitrogen, and must be addressed in the context of total dissolved gases.

Experiments involving the interaction of temperature with the lower limits of resistance of fish to reduced dissolved oxygen concentrations have resulted in extremely variable results. The lethal level of dissolved oyxgen concentrations has been reported to increase sometimes regularly and sometimes irregularly or not at all with increases of

TABLE 17

OXYGEN CRITERIA FOR ASSESSMENT
OF HARM IN VARIOUS FRESHWATER FISH GROUPS[a,b]

Group	Harm Commitment Level	Mg O_2/l	Percent Saturation At Each Temperature (°C) 0	5	10	15	20	25
Mixed fish population, including some salmonids	A	7.25	69	70	70	71	79	87
	B	5.25	54	54	54	54	57	63
	C	3.25	38	38	38	38	39	39
Mixed fish population, no salmonids	A	5.50	60	60	60	60	60	66
	B	4.00	47	47	47	47	47	48
	C	2.50	35	35	35	35	35	36
Salmonid larvae and mature eggs of salmonids	A	9.75	98	98	98	98	100	100
	B	8.00	76	76	76	79	87	95
	C	6.50	54	54	57	64	71	78

Harm (or Risk) Commitment Levels:

Level A: More or less ideal conditions (i.e, little or no foreseeable harm) which permits little depression of oxygen from full saturation. This level represents a standard that assures a high degree of safeguard for very important stocks.

Level B: Some degree of risk (i.e., possibility of moderate harm) to a portion of a fish population exists with this level if the oxygen minimum period is prolonged beyond a few hours.

Level C: A large portion of a given fish population or fish community may be affected by low oxygen at this level. This deleterious effect may be severe (i.e, possibility of severe harm), especially if the oxygen minimum is prolonged beyond a very few hours.

[a] Reproduced in part from Davis (1975a, b)

[b] These criteria are defined as minimum oxygen concentrations in percentage saturation allowable at maximum seasonal temperatures.

temperature within the range of temperatures to which fish are normally exposed in nature.

Air saturation in water decreases with an increase in water temperature (e.g., 12 mg/l O_2 = saturation at 6°C; 8 mg/l O_2 = saturation at 25°C). Several factors are interacting to determine what effect this physical process actually has on fish populations. At low temperatures the metabolic rate of fishes is reduced, when oxygen saturation is maximized, while at higher temperatures when growth is maximized dissolved oxygen concentrations are falling. Thus, it may be predicted that as oxygen concentration falls, the critical oxygen level permitting growth decreases with decreasing temperature (due to the decrease in the requirement for oxygen at a reduced metabolic rate). Doudoroff and Shumway (1970) reported some unpublished data from an experiment on largemouth bass, which are the only experiments which have been conducted in this context (Brett 1979). The results of these studies revealed that at lower temperatures the critical dissolved oxygen level was reduced, supporting the prediction that growth is still possible at a lower oxygen concentration only when temperature is reduced. Therefore, the pacing effect of temperature raises or lowers the critical level of dissolved oxygen concentration, or of any limiting factor.

The previous discussion involves the concept of limiting and controlling factors. Oxygen is considered a limiting factor, while temperature is controlling.

5.3.2 Temperature

The consideration of water temperature criteria and potential effects on fish resources involves several biological factors. Additionally, two aspects of temperature alteration should be evaluated: one being an increase in water temperature over ambient; and a second being a decrease in temperature in relation to ambient as could be the case downstream of a reservoir.

In evaluating the effects of increases in water temperature over ambient conditions, several principles warrant consideration. In terms of the effects of temperature on the growth of fishes, a rapid increase in growth rate typically occurs as temperature rises until an optimum point is reached, beyond which growth rates fall quickly. The lethal temperature for fishes is beyond the optimum temperature, a point which is important in evaluating potential impacts of altered temperature regimes. For example, although maximum temperatures may be maintained below lethal temperatures, if these temperatures are greater than the optimum the condition of the fish population could deteriorate significantly although no temperature-related deaths occur. The optimum temperatures for the coldwater fishes are lower than those of the warmwater species, as one would expect. The optimum temperature for rainbow trout is 17.2°C while that of the white sucker is 27°C (Brett 1979). To put these examples in context, the upper lethal temperature for rainbow trout has been reported as 25°C (Cherry et al. 1977). The upper lethal temperatures for white sucker ranged from 26°C when the fish were acclimated at 5°C, to 31°C when the fish were acclimated at a temperature of 26°C (Carlander 1969). The range of water temperature tolerated by walleye is 0 to 30°C, while the preferred temperature is in the range of 20 to 23°C (Ferguson 1958).

Furthermore, when growth rates are compared in fishes subjected to fluctuating temperatures (i.e., diurnal variation) and constant temperatures, the optimum occurs at a lower temperature where fluctuations occur, indicating that daily peak temperatures have a carry-over, beneficial effect when the thermal range applied occurs below the static optimum. This benefit declines where higher temperatures are involved, and is non-existent when the peak of fluctuation enters the fringe of temperature tolerance for the species (Brett 1979). The timing and extent of temperature changes on a seasonal level are also important, as they control such factors as breeding (Hynes 1970). Although warmwater fishes can tolerate winter temperatures, the water must warm up early enough and high enough to allow them to breed at the proper time. Conversely, water temperatures must fall below 14°C sometime during the year to allow trout to breed (Huet 1962).

The combined effects of water temperature and dissolved oxygen concentrations were discussed in the previous section of the report, while the effects of temperature and ammonia are considered in the following section. However, it should be understood that although temperature maxima and minima exist for each species of fish, temperature is a controlling factor rather than a limiting factor. Controlling factors (e.g., temperature, pressure) affect the metabolic rate through their influences on molecular activity, and set upper limits on the metabolic rate. Limiting factors are parameters such as metabolites, food, water and the respiratory gases (primary factors), and factors which influence the rate of exchange of the metabolites between the organism and its environment (secondary limiting factors) (Fry 1971). Oxygen, as previously discussed, is a limiting factor. As a controlling factor, temperature acts in conjunction, never in sequence, with other environmental factors.

5.3.3 Ammonia

The available literature is somewhat difficult to summarize and analyze in regard to ammonia, as researchers report the results of fish toxicity experiments as NH_3, NH_3-H, NH_4OH, total ammonia and total ammonia-nitrogen to name a few. Un-ionized ammonia should be referred to as NH_3, while NH_3-N refers to un-ionized ammonia-nitrogen, NH_4^+ to the ammonium ion, and total ammonia is $NH_3 + NH_4^+$.

The acute and chronic toxicity of unionized ammonia-nitrogen for some salmonid species found in the Oldman River are summarized in Table 18. Results are presented as NH_3-N as this is the scientifically acceptable method for reporting nitrogen-based compounds. An NH_3 value of 0.02 mg/l is approximately equal to 0.016 mg/l NH_3-N. For time periods of 1 to 4 days, the LC50 values (concentrations killing 50 percent of exposed organisms at a specific time of observation) reported for salmonids fall within the range of 0.2 to 0.7 mg/l (Willingham et al. 1979). Very little published data are available for long-term mortality tests for fishes of any species. Values reported for rainbow trout over a three-month period

(see Table 18) range from 5 percent mortality at 0.06 mg/l to 15 percent mortality at 0.23 mg/l (Willingham et al. loc. cit.).

Deleterious effects of sublethal exposure to ammonia include blood damage and inflammations (0.08 to 0.33 mg/l NH_3-N), reduced disease resistance and reduction in growth (0.22 mg/l NH_3-N), gill damage (0.25 to 0.30 mg/l NH_3-N), tissue disintegration in various organs (0.04 to 0.2 mg/l NH_3-N) and a reduction in food uptake and food assimilation (0.04 mg/l NH_3-N) (summarized from Willingham et al. 1979).

For evaluating NH_3 levels, consideration should be given to acute and chronic levels of toxicity. Lloyd and Orr (1969) determined that NH_3 concentrations less than 12 percent of the observed lethal concentration had no effect on water absorption rates of rainbow trout. This value was therefore considered to be the threshold level of ammonia intoxication. The EIFAC (1970) concluded that an un-ionized criterion of 12 percent of the lowest reported acutely lethal concentration was appropriate for protection of all species of freshwater fishes. Utilizing this philosophy, the lowest reported acute toxicity level of 0.3 mg/l (Table 18) would result in a "safe" concentration from the point of view of chronic toxicity of 0.036 mg/l. However, as pointed out by Willingham et al. (1979), this theory has not been proven by long-term bioassays. It is also worth mentioning that EIFAC (1970) employed an acute toxicity value of 0.2 mg/l derived from the literature, which has subsequently been illustrated to be an inaccurately computated value. As an additional aside, it appears that the US EPA (1977) criterion for NH_3 in freshwater systems of 0.02 mg/l was determined by applying an application factor of 0.1 to the same 0.2 mg/l value. However, the water quality division of the American Fisheries Society feels that the 0.02 mg/l NH_3 (0.016 mg/l NH_3-N) is appropriate for the protection of freshwater salmonids (Willingham et al. loc. cit.).

The literature is not extensive on the synergistic effects of temperature on ammonia toxicity to fishes. In general, the studies that have been conducted reveal that the toxicity of ammonia decreases with lower temperatures. This is attributed to a decrease in the concentration

TABLE 18

ACUTE AND CHRONIC TOXICITY OF UN-IONIZED AMMONIA NITROGEN FOR SOME SALMONIDS IN THE OLDMAN RIVER

Species	Acute Toxicity (LC50)	Chronic Toxicity
Rainbow Trout	0.41 mg/l - 2 days	0.06 mg/l - 5 percent mortality in 3 months
	0.3-0.6 mg/l - 24-48 hours	
	0.84 mg/l - 8.3 hours	0.11 mg/l - 5 percent mortality in 3 months
	0.5 mg/l - 5.5 hours	
	0.65 mg/l - 2 hours	0.23 mg/l - 15 percent mortality in 3 months
Cutthroat Trout	0.43-0.66 mg/l - 96 hours	

Source: Willingham et al. (1979)

of un-ionized ammonia present as water temperatures fall (Willingham et al. loc. cit.). However, it is possible that these findings only apply to temperatures above 10°C (EIFAC 1970). The EIFAC (loc. cit.) points out Brown (1968) showed that at 3°C, the threshold LC50 of un-ionized ammonia for rainbow trout is approximately one-half the value it is at 10°C. These data suggest that the increased toxicity of ammonia at low temperatures would cancel the effect of temperature on the dissociation of ammonia. The EIFAC (1970) states that this situation is important, therefore, if ammonia concentrations rise in rivers during the winter.

Several researchers have found that lower concentrations of dissolved oxygen can have a profound influence on ammonia toxicity, with the toxicity increasing as the dissolved oxygen decreases. Lloyd (1961) attributes this consequence to an increase in the ventilation rate by fishes which increases the exposure to the NH_3 molecules. However, a consideration of dissolved oxygen concentrations and water temperatures in evaluating ammonia toxicity would result in an elaborate model, a process which does not appear to be justified at present in the water quality evaluation process.

For the purposes of evaluating potential effects of NH_3 from the upstream impoundment, the following criteria may be employed:

Levels below 0.02 mg/l - No Impact
Levels above 0.02 mg/l
but less than 0.04 mg/l - Minor Negative Impact
Levels above 0.04 mg/l - Major Negative Impact

The value of 0.04 mg/l NH_3 was chosen as the threshold for major negative impacts on the basis of the views of EIFAC (1970), and corresponds to a theoretical level above which the potential exists for acute toxicity.

6.0 DISCUSSION

6.1 STREAMFLOW, HABITAT AND THE FISHERIES RESOURCE OF THE OLDMAN RIVER

6.1.1 Coldwater Fauna

6.1.1.1 Mountain Whitefish

Adult and juvenile mountain whitefish utilized all segments of the study area for feeding in 1985. These fish were most abundant in Segments 5 and 6, decreased in abundance with distance downstream in Segments 2, 3 and 4, and were uncommon in Segment 1. Previous researchers have found mountain whitefish throughout the study area in decreasing abundance with distance downstream (Fish and Wildlife Division files, Radford 1975, Longmore and Stenton 1981). The upstream segments, 5 and 6, contained abundant suitable habitat for rearing in 1985 as in previous years (O'Neil et al. 1982, Allan 1985).

Segments 5 and 6 of the river have been described as providing "coldwater " habitat; downstream of Brocket there is a transitional zone between cold and cool water (Longmore and Stenton 1981, Allan 1985). Below LNID, streamflow is decreased and water temperature increased through removal of water in summer for irrigation purposes. In 1985 streamflow in upstream areas of Segment 4 was still sufficient and temperature was low enough to support substantial numbers of mountain whitefish. Segments 2 and 3 however, contained limited suitable habitat during summer, especially upstream of the confluence with the Belly River where streamflow was extremely low.

Longmore and Stenton (1981) reported low fish productivity between the LNID Weir and the mouth of the Belly River. Areas such as large riffles or the confluences with the Belly and St. Mary's rivers provided suitable habitat in 1985. Segment 1 also experienced low discharges and high water temperatures and turbidities in 1985, and was

especially unsuitable for mountain whitefish downstream of the Lethbridge Weir. Information in Fish and Wildlife Division files indicate that mountain whitefish were common in Segment 1 of the study area during boat electrofishing in the summer and fall of 1983. Unusually low water levels in summer, 1985 may have prevented a similar abundance of mountain whitefish in this area in 1985 (Table 19).

Mountain whitefish fry utilized all of the study area except Segment 1 for feeding in 1985. Preferred habitats (shallow riffle run areas and small side channels) appear to have been most abundant in Segment 4 where fry were most common. Segments 5 and 6 contained fewer fry with distance upstream, possibly because velocities which generally increased with distance upstream were greater than preferred. O'Neil et al. (1982), in studying the river between the proposed damsite and the LNID Weir, also found greatest abundance of mountain whitefish fry in the downstream portion of this area. In Segments 2 and 3, numbers of fry decreased as distance downstream increased during 1985. The decrease in streamflow and increase in water temperature with distance downstream limited the amount of suitable habitat available in those segments.

Migrations of adult and juvenile mountain whitefish have been described for other rivers in Alberta (McCart and Jones 1975, Davies and Thompson 1976). Movements of mountain whitefish in the Oldman River have been documented in previous research (McCart 1978, O'Neil et al. 1982, IEC Beak 1985b). Tagging returns (n = 41) from the Oldman River in 1985 indicate that a large percentage of fish present near the proposed damsite in spring, 1985, remained in that vicinity through summer and fall. A small percentage travelled upstream to the Castle River during summer.

Movements related to spawning occurred in October, 1985. Both adults and juveniles appear to undertake these migrations. A downstream migration of mountain whitefish from Segment 6 to Segment 5 appears to occur in late September and early October. O'Neil et al. (1982) suggest that juveniles and adults migrated downstream to the Summerview Bridge in late September to mid-October, 1982. This movement was considered as post-

TABLE 19

COMPARISON OF HISTORIC STREAMFLOWS (m^3/s) AND THOSE WHICH OCCURRED IN THE OLDMAN RIVER STUDY AREA, 1985

Month	Brocket[a]			Lethbridge[b]		
	Historic Mean Monthly	Mean Monthly 1985	Percent of Historic Mean Monthly	Historic Mean Monthly	Mean Monthly 1985	Percent of Historic Mean Monthly
May	140.0	88.3	63.1	251.0	114.0	45.4
Jun	157.0	70.3	44.8	346.0	83.1	24.0
Jul	56.2	18.2	32.4	129.0	4.5	3.5
Aug	26.1	13.6	52.1	42.3	4.6	10.9
Sept	16.3	34.8	213.5	39.0	32.3	82.8
Oct	14.1	40.3	285.8	42.9	60.2	140.3

[a] Based on 1966 to 1982 period of record at WSC Station No. 05AA024

[b] Based on 1911 to 1982 period of record at WSC Station NO. 05AD007

spawning, although in 1985 most adult fish captured at the Summerview Bridge were still in spawning condition. Spawning occurs from late September to mid-October depending largely upon water temperature. In late October, 1985 mountain whitefish adults and juveniles were once more common in Segment 6 upstream of the Summerview Bridge while numbers decreased at the bridge. This suggests an upstream migration in late October, 1985. O'Neil et al. (1982) report a downstream migration to overwintering areas from the Summerview Bridge in mid- to late October, 1982. The upstream migration in 1985 may have been initiated by the unseasonal increase in fall flows (Table 19).

Spawning of mountain whitefish occurs in Segments 4, 5 and 6; Segment 5 appears to be most extensively used. Segment 6 is also used heavily used for spawning while Segment 4 has lower utilization. O'Neil et al. (1982) found that the area from the study reach in Segment 6 downstream to the bottom of Segment 6 was most extensively used for spawning in 1982. Segments 5 and 6 are critical habitat areas for mountain whitefish spawning and migrations.

Habitat availability in the summer and fall of 1985 was not that of a typical year. Due to drought conditions during summer, streamflows above and especially below LNID were extremely low, producing less suitable habitat in segments than would be present in an average year (Table 19). Greater than average precipitation in the fall of 1985 produced much greater streamflows than average (Table 19). This increased flow may have provided suitable spawning and overwintering habitat in areas not usually available, and allowed more extensive migrations than typical.

6.1.1.2 Rainbow Trout

Rainbow trout adults and juveniles appear to be the only two life-history stages of this species found within the study area. Previous researchers found that rainbow trout were most abundant upstream of the Town of Brocket, decreased in abundance downstream, and had a lower range

limit near Fort Macleod (Longmore and Stenton 1981, O'Neil et al. 1982, Allan 1985). In 1985, individuals were most common upstream of LNID, in Segments 5 and 6, where water temperatures were lowest and streamflows highest. Rainbow trout occurred occasionally in Segment 4 between LNID and Highway 2, but habitat conditions were not as suitable in this segment as upstream. Both adults and juveniles used these segments for rearing and feeding. Suitable spawning areas for rainbow trout are generally unavailable in the upstream end of the study area, and a lack of fry indicates negligible spawning activity. Adults were uniformally dispersed in Segments 5 and 6 in 1985, while juveniles were most common in the upstream areas.

There appears to have been an increase in the number of rainbow trout in Segments 5 and 6 in fall, 1985. This may be the result of a downstream migration by fish to overwintering areas in Segments 5 and 6. The area from above the proposed damsite down to Segment 5 may include critical habitat for fall migration and overwintering. Unusually high water levels in fall, 1985 may have provided more available overwintering areas than in a typical year.

6.1.1.3 Incidental Species

Cutthroat trout, bull trout and brown trout all occur rarely in the study area, and only above Fort Macleod. Of the three species, bull trout are most common; adults over 5 years of age are believed to inhabit the river near Brocket, and some upstream migration is associated with spawning (Longmore and Stenton 1981). All three species are thought to spawn upstream of the study area (Longmore and Stenton 1981).

6.1.2 Coolwater Fauna

6.1.2.1 Lake Whitefish

Adult lake whitefish are found occasionally throughout the study area; no juveniles or fry have been recorded. Upstream of the LNID Weir,

lake whitefish occur only rarely (Fish and Wildlife Division files, O'Neil et al. 1982, Allan 1985). During the fall of 1985, three adults were captured in Segment 6. This extended upstream migration may have been facilitated by the greater than average streamflow at that time. Adults captured in the fall of 1985, as well as in 1984 (IEC Beak 1985b), were in spawning condition indicating that spawning may occur in the Oldman River. The small number of fish present implies that spawning would be negligible. It appears that the Oldman River is used only by feeding adults which have migrated into the river from downstream rivers or reservoirs.

6.1.2.2 Northern Pike

Adult northern pike feed in all but Segment 6 of the Oldman River study area. They are most common in the downstream segments, especially Segment 1 where water temperatures are high and velocites low. Previous researchers have also found that northern pike are most abundant at the downstream end of the Oldman River but are common as far upstream as Fort Macleod (Fish and Wildlife Division files, McCart 1978). Upstream of Fort Macleod, rearing and overwintering habitat is sparse (Allan 1985).

The Oldman River is used for spawning by northern pike (McCart 1978). Most suitable spawning habitat appears to be in downstream segments. Migrations of northern pike within the Oldman River, possibly to spawning, feeding or overwintering areas, have been documented (McCart 1978, IEC Beak 1985b). Critical spawning and migration habitat is present downstream of Fort Macleod.

6.1.2.3 Walleye

Adult walleye commonly occur in the Oldman River downstream of the confluence with the Belly River, and rarely, upstream as far as Fort Macleod (Fish and Wildlife Division files, Allan 1985). No juveniles or

fry have been reported in the study area. Adults are thought to migrate upstream from the South Saskatchewan River to feed in summer, and return in the fall (McCart 1978). During years with low flow in summer, such as 1985, walleye may be restricted to the lower reaches of the Oldman River. High flows in fall, as in 1985, may allow walleye to overwinter in the Oldman River. Suitable walleye spawning habitat is present near Lethbridge (McCart 1978), but lack of fry and juveniles indicates negligible use under present conditions.

6.1.2.4 Sauger

Adult sauger are present in the Oldman River only as far upstream as the Highway 3 Bridge at Monarch. No juveniles or fry have been reported. Fish and Wildlife Division files indicate that sauger are abundant downstream of the St. Mary's River. These fish may migrate upstream from the South Saskatchewan River to feed in summer, and return or overwinter in fall, depending upon streamflows (Longmore and Stenton 1981).

6.1.2.5 Mooneye and Goldeye

Mooneye inhabited the lower segments of the Oldman River study area as far upstream as the Highway 3 Bridge. Warm pools and deeper slow-moving sections of the river provide feeding habitat for adults. These individuals probably migrate upstream from the South Saskatchewan River in summer and return in fall. Several of the mooneye captured during this study were unable to move up or downstream due to low water levels during the summer of 1985. This would likely not occur in a year with average streamflows.

Although no goldeye were captured during this study, previous researchers have found goldeye as far upstream as Fort Macleod (Fish and Wildlife Division files). Adult goldeye are thought to migrate from the South Saskatchewan River to feed (Longmore and Stenton 1981), and during

low flow summers may migrate back out of the Oldman River (McCart 1978).

The lower portion of the Oldman River study area provides critical habitat for migrations of mooneye and goldeye.

6.1.2.6 Lake Sturgeon

Some lake sturgeon may be found downstream of Lethbridge (Longmore and Stenton 1981). None were captured in the Oldman River study area during 1985. Suitable habitat for sturgeon [depth greater than 2 m with sand bottom (Haugen 1969)] appears to be present in the lowest reaches of the study area. It is possible that sturgeon may migrate to these areas from the South Saskatchewan River, to feed. Local anglers have reported that sturgeon have been observed as far upstream in the drainage as the mouth of the Castle River.

7.0 CONCLUSIONS

The "coldwater" section of the Oldman River, upstream of the LNID Weir, provides suitable habitat for all life-history stages of mountain whitefish and supports a flourishing population. The upstream region of this section, including the Oldman River damsite, contains critical habitat for mountain whitefish spawning. Mountain whitefish migrations to summer feeding areas throughout this section of the river, to spawning areas and to overwintering areas are thought to take place in this region of the river. This area also provides suitable habitat for rearing use by juvenile rainbow trout, and is occasionally used for feeding by adult rainbow trout. It appears that there is some downstream movement by rainbow trout to overwintering areas in the fall, and subsequent upstream movements to the headwater region of the river for spawning in the spring and feeding during the summer.

Downstream of LNID, in the "coolwater" section of the river, all life stages of mountain whitefish are found in generally decreasing abundance with distance downstream. Spawning habitat is uncommon in this region of the river but preferred fry nursery habitat is abundant in Segment 4. Rainbow trout juveniles and adults occasionally use the river downstream as far as the Highway 2 Bridge for rearing and feeding. Northern pike are common, and complete their entire life cycle in the river. Adults of other species such as lake whitefish, walleye, sauger, mooneye and goldeye appear to migrate in and out of the Oldman River from other rivers or reservoirs. Abundance apparently depends on streamflow, which dictates the success in passage over the Lethbridge Weir, as well as habitat availability during the summer months. The Oldman River was used by these fish primarily as a summer feeding and rearing area, but some overwintering may occur. Lake sturgeon generally occur downstream of the Lethbridge Weir, but have been reported to occur as far upstream as the mouth of the Castle River. Due to the very low water levels experienced during the summer of 1985, use of the coolwater section of the study area was minimal during the summer and fall seasons.

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APPENDIX I
TABLE 1

COMMON AND SCIENTIFIC NAMES OF FISH SPECIES[a]

Common	Scientific Name
lake sturgeon[b]	Acipenser fluvescens Rafinesque
white sturgeon[b]	Acipenser transmontanus Richardson
goldeye[b]	Hiodon alosoides (Rafinesque)
mooneye	Hiodon tergisus Lesueur
lake whitefish	Coregonus clupeaformis (Mitchill)
mountain whitefish	Prosopium williamsoni (Girard)
cutthroat trout	Salmo clarki Richardson
rainbow trout	Salmo gairdneri Richardson
brown trout	Salmo trutta Linnaeus
bull trout	Salvelinus confluentus (Suckley)
northern pike	Esox lucius Linnaeus
lake chub	Couesius plumbeus (Agassiz)
flathead chub	Hybopsis gracilis (Richardson)
emerald shiner	Notropis atherinoides Rafinesque
river shiner	Notropis blennius (Girard)
spottail shiner	Notropis hudsonius (Clinton)
longnose dace	Rhinichthys cataractae (Valenciennes)
pearl dace	Semotilus margarita (Cope)
quillback	Carpiodes cyprinus (Lesueur)
longnose sucker	Catostomus catostomus (Forster)
white sucker	Catostomus commersoni (Lacepede)
mountain sucker	Catostomus platyrhynchus (Cope)
shorthead redhorse	Moxostoma macrolepidotum (Lesueur)
trout-perch	Percopsis omiscomaycus (Walbaum)
burbot	Lota lota (Linnaeus)
brook stickleback	Culaea inconstans (Kirtland)
sauger	Stizostedion canadense (Smith)
walleye	Stizostedion vitreum vitreum (Mitchill)
spoonhead sculpin	Cottus ricei (Nelson)

[a] Nomenclature according to American Fisheries Society (1980).

[b] Fish species not encountered in the Oldman River study area, 1985.

APPENDIX I, TABLE 2
RECORD OF GILL NET SAMPLING IN THE OLDMAN RIVER STUDY AREA, JULY-OCTOBER, 1985

Gill Net Stn.	Segment	Location (River Kilometre[a])	Date	Mesh Size[b] (cm)	Duration of Set (h)	Catch (Total No. of Individuals) Catch per Unit Effort (No./h)													
						Mountain Whitefish Juv[c]	Whitefish Ad	Lake Whitefish Ad	Rainbow Trout Juv	Trout Ad	Northern Pike Ad	Sauger Ad	Walleye Ad	Mooneye Ad	Longnose Sucker Ad	White Sucker Juv	White Sucker Ad	Shorthead Redhorse Ad	TOTAL
GN1	4	224.5	Jul 7	8.9	18.00											(1)0.06	(3)0.17		(4)0.22
GN2	4	224.5	Jul 7	6.4	17.83		(2)0.11								(9)0.51		(6)0.34	(2)0.11	(19)1.07
GN3	6	312.4	Jul 10	6.4	17.00														(0)0.00
GN4	6	312.3	Jul 10	8.9	16.83					(1)0.06					(1)0.06		(3)0.18		(5)0.30
GN5	6	311.4	Jul 13	5.1	16.05		(4)0.25		(4)0.25						(5)0.31				(13)0.81
GN6	6	312.4	Jul 13	3.8	15.33		.		(1)0.07										(1)0.07
GN7	5	307.1	Jul 15	5.1	13.12														(0)0.00
GN8	4	229.2	Jul 23	5.1	14.18	(2)0.14	(2)0.14	(1)0.07			(1)0.07				(8)0.56	(3)0.21	(5)0.35	(1)0.07	(23)1.62
GN9	4	229.1	Jul 23	6.4	15.03		(1)0.07	(1)0.07			(4)0.27				(8)0.53	(1)0.07	(4)0.27	(5)0.33	(24)1.60
GN10	3	205.0	Jul 25	6.4	14.25		(1)0.07				(1)0.07		(3)0.21						(5)0.35
GN11	3	205.0	Jul 25	5.1	13.07		(5)0.38				(2)0.15	(2)0.15		(1)0.08					(10)0.77
GN12	2	197.0	Jul 28	8.9	12.65		(1)0.08				(1)0.08		(4)0.32		(49)3.87		(9)0.71		(64)5.06
GN13	2	196.5	Jul 28	6.4	13.20		(1)0.08					(1)0.08	(8)0.61		(22)1.67				(32)2.43
GN14	2	172.1	Jul 30	8.9	13.92								(3)0.22				(1)0.07		(4)0.29
GN15	2	172.0	Jul 30	6.4	14.00						(2)0.14							(1)0.07	(3)0.21
GN16	1	166.5	Jul 31	6.4	12.25														(0)0.00
GN17	1	166.4	Jul 31	8.9	11.98						(2)0.17			(2)0.17	(1)0.08		(2)0.17	(1)0.08	(8)0.67
GN18	1	118.5	Aug 2	7.6	15.58						(4)0.26	(8)0.51	(1)0.06		(24)1.54		(11)0.71		(48)3.08
GN19	1	119.0	Aug 2	6.4	15.92						(1)0.06				(31)1.95		(2)0.13		(34)2.14
GN20	1	119.1	Aug 2	8.9	16.08							(1)0.06			(47)2.92		(42)2.61	(1)0.06	(91)5.66
GN21	6	312.3	Oct 2	5.1	14.80		(3)0.20		(10)0.68	(1)0.07									(14)0.95
GN22	6	312.4	Oct 2	6.4	14.15		(1)0.07			(3)0.21									(4)0.28
GN23	6	311.4	Oct 3	5.1	14.00				(1)0.07										(1)0.07
GN24	5	307.6	Oct 3	6.4	13.87		(1)0.07		(1)0.07	(1)0.07									(3)0.22
GN25	4	224.5	Oct 4	8.9	13.75														(0)0.00
GN26	4	224.4	Oct 4	6.4	13.63														(0)0.00
GN27	2	196.5	Oct 5	6.4	16.47														(0)0.00
GN28	2	197.0	Oct 5	8.9	16.48			(1)0.06									(1)0.06		(2)0.12
GN29	2	172.1	Oct 6	8.9	16.50														(0)0.00
GN30	2	172.0	Oct 6	6.4	16.17														(0)0.00
GN31	1	119.1	Oct 7	6.4	14.50							(1)0.07	(1)0.07						(2)0.14
GN32	1	118.5	Oct 7	8.9	14.45						(4)0.28								(4)0.28
TOTAL					475.04	(2)0.01	(22)0.05	(3)0.01	(17)0.04	(6)0.01	(22)0.05	(13)0.03	(20)0.04	(3)0.01	(205)0.43	(5)0.01	(89)0.19	(11)0.02	(418)0.88

[a] Distance in kilometres from the Grand Forks.
[b] All gill nets were 15.2 metres in length x 2.4 metres in depth.
[c] Life History Stage: Juv - Juvenile; Ad - Adult

APPENDIX I, TABLE 3

RECORD OF BOAT ELECTROFISHING IN THE OLDMAN RIVER STUDY AREA, JULY - OCTOBER, 1985

Catch

(Total No. of Individuals) Catch per Unit Effort (No./100s)

Date	Segment	Location (River Kilometre)[a]	Effort (s)	Mountain Whitefish				Lake Whitefish	Rainbow Trout		Brown Trout	Cutthroat Trout	Bull Trout	Northern Pike	Burbot	Sauger	Walleye
				F[b]	Juv		Ad	Ad	Juv	Ad	Juv	Juv	Juv	Ad	Ad	Ad	Ad
Jul 07	4	224.5-224.7	351														
Jul 12	6	312.5-313.0	601	(1)0.17	(50)	8.32	(40) 6.66		(1)0.17								
Jul 15	5	306.0-308.6	901	(3)0.33	(18)	2.00	(12) 1.33		(1)0.11	(1)0.11							
Jul 26	3	205.0-205.2	648													(1)0.15	(4)0.62
Jul 27	3	205.0-205.2	845				(1) 0.12							(0)0.12			
Jul 31	1	165.8-166.7	965														(1)0.10
Oct 02	6	313.0-316.0	886		(1)	0.11	(4) 0.45		(1)0.11	(1)0.11							
Oct 03	6	310.6-311.8	912	(1)0.11			(1) 0.11		(3)0.33	(1)0.11							
Oct 03	5	308.6-310.6	304	(1)0.33	(407)	133.88	(1626)534.87		(2)0.66	(1)0.33							
Oct 04	*4	227.6-230.0	1137	(3)0.26	(53)	4.66	(32) 2.81										
Oct 04	4	224.5-224.7	216		(5)	2.31	(3) 1.39										
Oct 05	2	196.1-198.5	1335	(2)0.15	(11)	0.82	(6) 0.45							(1)0.07			
Oct 07	1	118.4-120.0	2010														
Oct 09	2	167.0-172.0	2226		(12)	0.54	(5) 0.22							(1)0.04			
Oct 12	6	310.6-311.8	784	(2)0.26			(13) 1.66										
Oct 12	5	308.6-310.6	411	(1)0.24	(1)	0.24	(58) 14.11										
Oct 13	5	287.8-308.9	5023	(4)0.08	(166)	3.30	(920) 18.32		(2)0.04	(4)0.08		(1)0.02		(1)0.02	(5)0.10		
Oct 14	4	255.5-278.0	7382	(11)0.15	(216)	2.93	(156) 2.11		(6)0.08	(4)0.05	(1)0.01		(1)0.01	(1)0.01			
Oct 15	6	310.6-316.0	750	(1)0.13	(21)	2.80	(156) 20.80		(1)0.13	(1)0.13					(7)0.93		
Oct 15	5	308.6-310.6	358	(1)0.28	(1042)	291.06	(124) 34.64			(1)0.28					(1)0.28		
Oct 16	5	278.0-287.8	2692		(126)	4.68	(162) 6.02		(1)0.04	(6)0.22							
Oct 17	6	315.6-316.0	124		(22)	17.74	(30) 24.19										
Oct 19	6	311.4-316.0	1224	(1)0.08	(45)	3.68	(77) 6.29	(3)0.25		(1)0.08							
Oct 21	6	310.6-311.4	1057	(1)0.09	(25)	2.37	(67) 6.34										
TOTAL			33142	(33)0.10	(2221)	6.70	(3493) 10.54	(3)0.01	(18)0.05	(21)0.06	(1)0.01	(1)0.01	(1)0.01	(5)0.15	(13)0.04	(1)0.01	(5)0.02

continued . . .

Appendix I, Table 3 (continued)

Date	Segment	Location (River Kilometre)[a]	Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)															
				Mooneye	Longnose Sucker			White Sucker			Shorthead Redhorse	Mountain Sucker		Unidentified Sucker		Longnose Dace		Pearl Dace
				Ad	Juv	Ad	F	Juv	Ad		Ad	Juv	Ad	Juv	Ad	Juv	Ad	Ad
Jul 07	4	224.5-224.7	351						(12)3.42				(4)1.14	(50)14.25					
Jul 12	6	312.5-313.0	601			(24)3.99			(20)3.33				(50)8.32						
Jul 15	5	306.0-308.6	901		(5)0.55	(14)1.55			(14)1.55				(5)0.55				(55)6.10		
Jul 26	3	205.0-205.2	648					(3)0.46	(16)2.47		(1)0.15								
Jul 27	3	205.0-205.2	865	(1)0.12															
Jul 31	1	165.8-166.7	965																
Oct 02	6	313.0-316.0	886																
Oct 03	6	310.6-311.8	912			(11)1.21			(3)0.33								(3)0.33		
Oct 03	5	308.6-310.6	304		(1)0.33	(20)6.58											(3)0.99		(1)0.33
Oct 04	4	227.6-320.0	1137			(25)2.20	(2)0.18		(16)1.41				(2)0.18		(26)2.29				
Oct 04	6	224.5-224.7	216			(5)2.31			(1)0.46										
Oct 05	2	196.1-198.5	1335			(12)0.90		(1)0.07	(8)0.60		(1)0.07				(16)1.20				
Oct 07	1	118.4-120.0	2010			(4)0.20		(2)0.10	(5)0.25							(12)0.60			
Oct 09	2	167.0-172.0	2226			(8)0.36													
Oct 12	6	310.6-311.8	784			(3)0.38			(2)0.26										
Oct 12	5	308.6-310.6	411			(13)3.16													
Oct 13	5	287.8-308.9	5023			(108)2.15			(23)0.46										
Oct 14	4	255.5-278.0	7382			(33)0.45			(21)0.28			(2)0.03							
Oct 15	6	310.6-316.0	750			(52)6.93			(5)0.67										
Oct 15	5	308.6-310.6	358			(30)8.38			(12)3.35										
Oct 16	5	278.0-287.8	2692			(18)0.67			(2)0.07										
Oct 19	6	315.6-316.0	124																
Oct 19	6	311.4-316.0	1224			(10)0.82			(3)0.25										
Oct 21	6	310.6-311.4	1057			(16)1.51			(5)0.47										
TOTAL			33142	(1)0.01	(6)0.02	(406)1.23	(2)0.01	(6)0.01	(168)0.51		(2)0.01	(2)0.01	(61)0.18	(50)0.15	(42)0.13	(12)0.04	(61)0.18		(1)0.01

continued . . .

Appendix I, Table 3 (continued)

Date	Segment	Location (River Kilometre)[a]	Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s) Trout-Perch Ad	Emerald Shiner Juv	Emerald Shiner Ad	Spottail Shiner Ad	TOTAL
Jul 07	4	224.5-224.7	351	(1) 0.28			(12) 3.42	(79) 22.51
Jul 12	6	312.5-313.0	601				(1) 0.17	(187) 31.11
Jul 15	5	306.0-308.6	901					(128) 14.21
Jul 26	3	205.0-205.2	648					(25) 3.86
Jul 27	3	205.0-205.2	845					(3) 0.35
Jul 31	1	165.8-166.7	965	(100) 10.36		(100) 10.36	(100) 10.36	(301) 31.19
Oct 02	6	313.0-316.0	886					(7) 0.79
Oct 03	6	310.6-311.8	912					(23) 2.52
Oct 03	5	308.6-310.6	304					(2062) 678.29
Oct 04	4	227.6-320.0	1137					(159) 13.98
Oct 04	4	224.5-224.7	216					(14) 6.48
Oct 05	2	196.1-198.5	1335					(58) 4.34
Oct 07	1	118.4-120.0	2010	(1) 0.05	(24) 1.19	(1) 0.05		(49) 2.44
Oct 09	2	167.0-172.0	2226					(26) 1.17
Oct 12	6	310.6-311.8	784					(20) 2.55
Oct 12	5	308.6-310.6	411					(73) 17.76
Oct 13	5	287.8-308.9	5023					(1234) 24.57
Oct 14	4	255.5-278.0	7382					(452) 6.12
Oct 15	6	310.6-316.0	750					(244) 32.53
Oct 15	5	308.6-310.6	358					(1211) 338.27
Oct 16	5	278.0-287.8	2692					(315) 11.70
Oct 19	6	315.6-316.0	124					(52) 41.94
Oct 19	6	311.4-316.0	1224					(140) 11.44
Oct 21	6	310.6-311.4	1057					(114) 10.79
TOTAL			33142	(102) 0.31	(24) 0.07	(101) 0.30	(113) 0.34	(6976) 21.05

[a] Distance in kilometres from the Grand Forks.

[b] Life history stage: F = Fry; Juv = Juvenile; Ad = Adult.

APPENDIX I, TABLE 4
RECORD OF BACKPACK ELECTROFISHING IN THE OLDMAN RIVER STUDY AREA, JULY - AUGUST, 1985

Date	Segment	Location (River Kilometre)[a]	Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)												
				Mountain Whitefish			Burbot		Sauger	Longnose Sucker		White Sucker				Shorthead Redhorse
				F[b]	Juv	Ad	Juv	Ad	Ad	Juv	Ad	F	Juv	Ad		Ad
Jul 13	6	312.5	468													
	6	312.3-312.5	545													
	6	311.5-311.7	430													
	6	310.6-311.5	581													
	5	308.8-309.2	412									(4)0.97				
Jul 17	5	281.7	587													
	5	279.8-281.7	720									(3)0.42				
	4	277.8-278.0	194													
	4	277.6-277.8	116													
	4	277.4-277.6	232													
Jul 18	4	224.3-224.7	612	(4)0.65												
	4	223.7-224.3	993													
Jul 28	2	197.9-198.5	329		(1)0.30	(83)25.23					(85)25.84				(10)3.04	(5) 1.52
Jul 31	1	166.4-167.0	483		(10)2.07								(1)0.21			
Aug 01	1	156.1	617			(28)4.54	(1)0.16				(76)12.32					(66)10.70
Aug 02	1	119.3-120.2	300				(1)0.33	(1)0.33		(5)1.67						
	1	121.3-121.7	150					(1)0.67		(1)0.67	(1)0.67					
Aug 03	1	97.1- 97.5	1036						(1)0.10				(1)0.10			
TOTAL			8805	(4)0.05	(11)0.12	(111)1.26	(2)0.02	(2)0.02	(1)0.01	(6)0.07	(162)1.84	(7)0.08	(2)0.02	(10)0.11		(71)0.81

Appendix I, Table 4 (concluded)

Date	Segment	Location (River Kilometre)[a]	Effort (s)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)										
				Mountain Sucker		Longnose Sucker		Dace	Trout-Perch	Emerald Shiner	Spottail Shiner	Flathead Chub	Spoonhead Sculpin	
				Juv	Ad	F	Juv	Ad	Ad	Ad	Ad	Ad	Ad	TOTAL
Jul 13	6	312.5	468		(5) 1.07			(150) 32.05	(6) 1.28					(161) 34.40
	6	312.3-312.5	545		(2) 0.37			(20) 3.67						(22) 4.04
	6	311.5-311.7	430		(40) 9.30			(150) 34.88	(3) 0.70				(1)0.23	(194) 45.12
	6	310.6-311.5	581		(5) 0.87			(30) 5.16	(10) 1.72					(45) 7.75
	5	308.8-309.2	412					(95) 23.06	(39) 9.47					(143) 34.71
Jul 17	5	281.7	587	(5)1.21				(50) 8.52						(50) 8.52
	5	279.8-281.7	720					(50) 6.94	(18) 2.50					(71) 9.86
	4	277.8-278.0	194		(20)10.31			(50) 25.77	(70)36.08					(140) 72.17
	4	277.6-277.8	116	(1)0.86					(4) 3.45					(5) 4.31
	4	277.4-277.6	232						(11) 4.74					(11) 4.74
Jul 18	4	224.3-224.7	612	(8)1.31		(1)0.16		(228) 37.26	(41) 6.70					(282) 46.08
	4	223.7-224.3	993					(30) 3.02						(30) 3.02
Jul 28	2	197.9-198.5	329											(184) 55.93
Jul 31	1	166.4-167.0	483		(11) 2.28		(5) 1.04	(35) 7.25				(1)0.21		(63) 13.04
Aug 01	1	156.1	617		(200)32.41			(1000)162.08						(1371)222.20
Aug 02	1	119.3-120.2	300		(1) 0.33		(75)25.00	(300)100.00						(383)127.67
	1	121.3-121.7	150				(30)20.00	(70) 46.67						(103) 68.67
Aug 03	1	97.1- 97.5	1036		(5) 0.48		(250)24.13	(750) 72.39		(1)0.10	(1)0.10			(1009) 97.39
TOTAL			8805	(14)0.16	(289) 3.28	(1)0.01	(360) 4.09	(3008) 34.16	(202) 2.29	(1)0.01	(1)0.01	(1)0.01	(1)0.11	(4267) 48.46

[a] Distance in kilometres from the Grand Forks.
[b] Life history stages: F = fry; Juv = Juvenile; Ad = Adult.

APPENDIX I, TABLE 5
RECORD OF SEINE NET SAMPLING IN THE OLDMAN RIVER STUDY AREA, JULY - OCTOBER, 1985

Date	Segment	Location (River Kilometre)[a]	Sampling Effort No. of Seine Hauls	Total Area (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)										
					Mountain Whitefish			Northern Pike	Longnose Sucker			White Sucker			
					F[b]	Juv	Ad	Ad	F	Juv	Ad	F	Juv	Ad	
Jul 07	4	224.7	7	372									(141)37.90		
Jul 11	6	312.5-313	12	687						(1)0.15					
Jul 12	6	312.4	3	2220[c]											(2)0.09
Jul 13	5	308.9	3	310											
Jul 15	5	306.1-308.6	10	610	(2)0.30				(13) 1.94	(13)1.94		(89) 13.28	(1) 0.15		
Jul 17	5	279.8-281.7	4	279	(1)0.36				(8) 2.87			(7) 2.51	(86)30.82		
Jul 17	4	277.1-278.0	13	800	(9)1.13							(1) 0.13			
Jul 18	4	223.2-224.7	5	273	(8)2.93					(13)4.76		(3) 1.10			
Jul 23	4	228.4-230.0	4	460[d]	(1)0.22	(60)13.04	(33)7.17				(1)0.22				(1)0.22
Jul 25	2	198.1-198.5	8	412	(1)0.24	(4) 0.97	(7)1.70		(1) 0.24			(33) 8.01	(9)2.18		
Jul 25	3	205.0-205.3	3	450[d]						(2)0.44			(7)1.56		
Jul 25	3	205.3-205.4	3	86						(1)1.16		(12) 13.95	(4)4.65		
Jul 26	3	209.4-209.6	2	60								(21) 35.00			
Jul 27	3	221.6-222.0	3	69	(1)1.45							(6) 8.70	(29)42.02		
Jul 28	2	190.6-191.0	5	79									(1) 1.27		
Jul 31	1	166.9	1	36[d]											
Jul 31	1	166.4-166.8	3	110											
Aug 01	1	155.9	1	14											
Aug 02	1	118.4-118.2	4	155				(1)0.65	(681)439.35			(801)516.77			
Aug 03	1	91.8- 98.3	5	182					(12) 6.59	(1)0.55		(24) 13.19	(62)34.07		
Oct 06	2	168.1-169.0	8	70[c]								(1) 0.14			
TOTAL	minnow seine		88	4558	(22)0.48	(4)0.09	(7)0.15	(1)0.02	(715)15.69	(29)0.64		(997)21.87	(333)7.31		
	large mesh seine		3	2220											(2)0.01
	river seine		8	946	(1)0.11	(60)6.34	(33)3.49			(2)0.21	(1)0.11		(7)0.74		(1)0.11
	minnow seine		8	710								(1)0.14			
GRAND TOTAL			107	8434	(23)0.27	(64)0.76	(40)0.47	(1)0.01	(715)8.48	(31)0.37	(1)0.01	(998)11.83	(340)4.03		(3)0.04

Appendix I, Table 5 (continued)

Date	Segment	Location (River Kilometre)[a]	Sampling Effort No. of Seine Hauls	Total Area (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)											
					Shorthead Redhorse			Mountain Sucker		Quillback	Unidentified Sucker			Longnose Dace		
					F	Juv	Ad	F	Juv	F	F	Juv	F	Juv		Ad
Jul 07	4	224.7	7	372								(83)22.31		(7) 1.88		(79) 21.24
Jul 11	6	312.5-313	12	687					(4)0.58					(1) 0.15		(73) 10.63
Jul 12	6	312.4	3	2220[c]												
Jul 13	5	308.9	3	310					(1)0.32							(19) 6.13
Jul 15	5	306.1-308.6	10	610								(1) 0.15				(19) 2.84
Jul 17	5	279.8-281.7	4	279										(5) 1.79		(7) 2.51
Jul 17	4	277.1-278.0	13	800												(56) 7.00
Jul 18	4	223.2-224.7	5	273				(5)1.83			(22)8.05					(70) 25.64
Jul 23	4	228.4-230.0	4	460[d]			(6)1.30									(1) 0.22
Jul 25	2	198.1-198.5	8	412				(1)0.24						(61) 14.81		(451)109.47
Jul 25	3	205.0-205.3	3	450[d]		(5)1.11			(27)6.00							(16) 3.56
Jul 25	3	205.3-205.4	3	86										(56) 65.12		(491)570.93
Jul 26	3	209.4-209.6	2	60				(1)1.67						(22) 36.67		(338)563.33
Jul 27	3	221.6-222.0	3	69		(2)2.90								(9) 13.04		(16) 23.19
Jul 28	2	190.6-191.0	5	79					(3)3.80					(47) 59.49		(91)115.19
Jul 31	1	166.9	1	36[d]	(4)3.64											
Jul 31	1	166.4-166.8	3	110										(1) 0.91		(13) 11.82
Aug 01	1	155.9	1	14										(19)135.71		(119)850.00
Aug 02	1	118.4-118.2	4	155									(13)8.39	(49) 31.61		(11) 7.10
Aug 03	1	91.8- 98.3	5	182						(3)1.65				(99) 54.40		(59) 32.42
Oct 06	2	168.1-169.0	8	70[c]												
TOTAL	minnow seine		88	4558				(7)0.15	(8)0.18	(3)0.07	(22)0.48	(84)1.84	(13)0.29	(376)8.25		(1912)41.95
	large mesh seine		3	2220												
	river seine		8	946		(5)0.53	(6)0.63		(27)2.85							(17)1.80
	minnow seine		8	710												
GRAND TOTAL			107	8434	(4)0.05	(7)0.08	(6)0.07	(7)0.08	(35)0.42	(3)0.04	(22)0.26	(84)0.26	(13)0.15	(376)4.46		(1929)22.87

continued . . .

Appendix I, Table 5 (continued)

Date	Segment	Location (River Kilometre)[a]	Sampling Effort No. of Seine Hauls	Total Area (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s)							
					Trout Perch		Emerald Shiner		Spottail Shiner		River Shiner	
					Juv	Ad	Ad	F	Juv	Ad	Juv	Ad
Jul 07	4	224.7	7	372		(6)1.61	(38)10.22			(26)6.99	(11)2.96	(2)0.54
Jul 11	6	312.5-313	12	687								
Jul 12	6	312.4	3	2220[c]								
Jul 13	5	308.9	3	310		(1)0.32						
Jul 15	5	306.1-308.6	10	610		(47)7.01			(1)0.15			
Jul 17	5	279.8-281.7	4	279	(6)2.15	(18)6.45						
Jul 17	4	277.1-278.0	13	800		(2)0.25						
Jul 18	4	223.2-224.7	5	273		(2)0.73						
Jul 23	4	228.4-230.0	4	460[d]								
Jul 25	2	198.1-198.5	8	412	(23)5.34					(4)0.97		
Jul 25	3	205.0-205.3	3	450[d]		(220)48.89	(27)6.00			(20)4.44		
Jul 25	3	205.3-205.4	3	86	(2)2.33		(36)41.86			(31)36.05		
Jul 26	3	209.4-209.6	2	60		(2)3.33	(2)3.33			(5)8.33		
Jul 27	3	221.6-222.0	3	69	(9)13.04	(1)1.45	(24)34.78					
Jul 28	2	190.6-191.0	5	79		(2)2.53	(2)2.53		(50)63.29	(16)20.25		
Jul 31	1	166.9	1	36[d]								
Jul 31	1	166.4-166.8	3	110			(4)3.64					
Aug 01	1	155.9	1	14								
Aug 02	1	118.4-118.2	4	155		(13)8.39	(12)7.74	(8)5.16	(1)0.65	(2)1.29	(9)5.81	(62)40.00
Aug 03	1	91.8- 98.3	5	182	(12)6.59	(9)4.95	(3)1.65		(15)8.24	(34)18.68		
Oct 06	2	168.1-169.0	8	70[c]		(2)0.28						
TOTAL	minnow seine		88	4558	(51)1.12	(103)2.26	(121)2.65	(8)0.18	(67)1.47	(118)2.59	(20)0.44	(64)1.40
	large mesh seine		3	2220								
	river seine		8	946		(220)23.26	(27)2.85			(20)2.11		
	minnow seine		8	710		(2)0.29						
GRAND TOTAL			107	8434	(51)0.60	(325)3.85	(148)1.75	(8)0.09	(67)0.79	(138)1.64	(20)0.24	(64)0.76

continued . . .

Appendix I, Table 5 (concluded)

Date	Segment	Location (River Kilometre)[a]	Sampling Effort No. of Seine Hauls	Total Area (m^2)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100s) Lake Chub F	Juv	Ad	TOTAL
Jul 07	4	224.7	7	372				(393) 105.64
Jul 11	6	312.5-313	12	687				(79) 11.50
Jul 12	6	312.4	3	2220[c]				(2) 0.09
Jul 13	5	308.9	3	310				(21) 6.77
Jul 15	5	306.1-308.6	10	610			(4)0.60	(190) 28.36
Jul 17	5	279.8-281.7	4	279			(2)0.72	(140) 50.18
Jul 17	4	277.1-278.0	13	800				(68) 8.50
Jul 18	4	223.2-224.7	5	273				(123) 45.05
Jul 23	4	228.4-230.0	4	460[d]				(103) 22.39
Jul 25	2	198.1-198.5	8	412				(594) 144.17
Jul 25	3	205.0-205.3	3	450[d]			(1)0.22	(1325) 72.22
Jul 25	3	205.3-205.4	3	86			(1)1.16	(634) 737.21
Jul 26	3	209.4-209.6	2	60				(391) 651.67
Jul 27	3	221.6-222.0	3	69			(2)2.90	(99) 143.48
Jul 28	2	190.6-191.0	5	79				(212) 268.35
Jul 31	1	166.9	1	36[d]				(0) 0.00
Jul 31	1	166.4-166.8	3	110				(22) 20.00
Aug 01	1	155.9	1	14				(138) 985.71
Aug 02	1	118.4-118.2	4	155	(2)1.29			(1665)1074.19
Aug 03	1	91.8- 98.3	5	182		(3)1.65	(5)2.75	(341) 187.36
Oct 06	2	168.1-169.0	8	70[c]				(3) 0.42
TOTAL	minnow seine		88	4558	(2)0.04	(3)0.07	(14)0.33	(5110) 112.11
	large mesh seine		3	2220				(2) 0.09
	river seine		8	946			(1)0.11	(428) 45.24
	minnow seine		8	710				(3) 0.42
GRAND TOTAL			107	8434	(2)0.02	(3)0.04	(15)0.19	(5543) 65.72

[a] Life history stage: F = Fry; Juv = Juvenile; Ad = Adult.
[b] Large mesh seine = 15.0 m x 2.0 m, 8.9 cm mesh.
[c] River seine = 14.8 m x 3.9 m, 1.4 mesh.
[d] Minnow seine = 7.6 m x 1.2 m, 1.1 cm mesh.
All other seine hauls conducted with 6.2 m x 1.1 m, 0.8 cm mesh minnow seine.

APPENDIX I, TABLE 6

RECORD OF FISH OBSERVED WHILE FLOATING IN THE OLDMAN RIVER STUDY AREA, JULY- OCTOBER, 1985[a]

Date	Segment	Location (River Kilometre)[b]	Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100m)										
				Mountain Whitefish			Rainbow Trout		Burbot	Longnose Sucker	White Sucker		Shorthead Redhorse
				F[c]	Juv	Ad	Juv	Ad	Ad	Ad	Juv	Ad	Ad
Jul 18	4	224.2	1 000	(31) 3.10	(9) 0.90								
Jul 24	4	229.8	1 400	(508)36.29	(104) 7.43	(3) 0.21							
Jul 27	3	221.7	500	(26) 5.20	(1) 0.20								
Jul 28	2	191.0	1 500	(2) 0.13	(61) 4.07	(20) 1.33				(10)0.67			(2)0.13
Jul 30	2	180.5	500		(32) 6.40	(40) 8.00				(24)4.80			(2)0.40
Aug 4	6	311.6	1 500	(16) 1.07	(7) 0.47			(2)0.13					
Aug 4	5	308.6	2 500	(20) 0.80	(60) 2.40	(25) 1.00	(3)0.12			(13)0.52		(9)3.60	
Aug 5	6	316.0	4 300	(35) 0.81	(320) 7.44	(271) 6.30	(8)0.19			(208)4.84	(1)0.02	(69)1.60	
Aug 5	6	313.0	1 500	(3) 0.20	(114) 7.60	(60) 4.00	(16)1.07	(1)0.07		(12)0.80		(8)0.53	
Aug 6	6	316.0	4 300	(24) 0.56	(118) 2.74	(50) 1.16	(6)0.14			(155)3.60		(10)0.23	
Aug 6	6	313.0	1 500	(16) 1.07	(114) 7.60	(115) 7.67	(12)0.80			(18)1.20		(15)1.00	
Aug 27	4	225.7	1 000		(200)20.00	(200)20.00							(1)0.10
Aug 28	6	316.0	4 300	(22) 0.51	(337) 7.84	(341) 7.93	(23)0.53		(2)0.05	(69)1.60		(12)0.28	
Oct 2	6	316.0	4 300			(1) 0.02		(1)0.02		(37)0.86		(2)0.05	
Total			30 100	(703) 2.34	(1477) 4.91	(1126) 3.74	(68)0.23	(4)0.01	(2)0.01	(546)1.81	(1)0.01	(125)0.42	(5)0.02

continued . . .

Appendix I, Table 6 (concluded)

Date	Segment	Location (River Kilometre)[b]	Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No./100m)							
				Mountain Sucker			Longnose Dace	Emerald Shiner	Spottail Shiner	Lake Chub	
				F[c]	Juv	Ad	Ad	Ad	Ad	Ad	TOTAL
Jul 18	4	224.2	1 000								(40) 4.00
Jul 24	4	229.8	1 400								(615) 43.93
Jul 27	3	221.7	500								(27) 5.40
Jul 28	2	191.0	1 500		(80) 5.33	(120) 8.00	(700)46.67				(995) 66.33
Jul 30	2	180.5	500		(50)10.00	(53)10.60	(200)40.00	(5)1.00	(10)2.00	(10)2.00	(426) 85.20
Aug 4	6	311.6	1 500								(25) 1.67
Aug 4	5	308.6	2 500								(130) 5.20
Aug 5	6	316.0	4 300			(3) 0.07					(915) 21.28
Aug 5	6	313.0	1 500	(1)0.07	(34) 2.27	(86) 5.73					(335) 22.33
Aug 6	6	316.0	4 300			(10) 0.23					(373) 8.67
Aug 6	6	313.0	1 500			(122) 8.13					(412) 27.47
Aug 27	4	225.7	1 000								(401) 40.10
Aug 28	6	316.0	4 300		(2) 0.05						(808) 18.79
Oct 2	6	316.0	4 300								(41) 0.95
Total			30 100	(1)0.01	(166) 0.55	(394) 1.31	(900) 2.99	(5)0.02	(10)0.03	(10)0.03	(5543) 18.42

[a] Fish observed while collecting habitat use data are not included.
[b] Distance in kilometres from the Grand Forks.
[c] Life history stage: F = Fry; Juv = Juvenile; Ad = Adult.

APPENDIX I, TABLE 7

RECORD OF FISH OBSERVED FROM THE SURFACE IN THE OLDMAN RIVER STUDY AREA, JULY, 1985

Date	Study Segment	Location (River Kilometre)[a]	Sampling Effort (m)	Catch (Total No. of Individuals) Catch per Unit Effort (No. /100m)											
				Mountain Whitefish			Longnose Sucker	White Sucker		Shorthead Redhorse	Mountain Sucker	Emerald Shiner	Spottail Shiner	Lake Chub	TOTAL
				F[b]	Juv	Ad	Ad	Juv	Ad	Ad	Ad	Ad	Ad	Ad	
Jul 17	4	277.0	500	(71)14.20	(100)20.00				(12)2.40						(183)36.60
Jul 18	4	274.2	1 000	(74) 7.40											(74) 7.40
Jul 25	2	198.5	100		(4) 4.00	(9)9.00									(13) 13.00
Jul 25	3	205.5	500	(4) 0.80	(6)1.20										(10) 2.00
Jul 26	3	216.0	225		(29)12.89	(8)3.56	(6)2.67	(3)1.33	(3)1.33	(3)1.33	(30)13.33	(50)22.22	(30)13.33	(200)88.89	(362) 160.88
Jul 27	3	221.7	200	(15) 7.50											(15) 7.50
TOTAL			2525	(164) 6.50	(139) 5.50	(17)0.67	(6)0.24	(3)0.12	(15)0.59	(3)0.12	(30) 1.19	(50) 1.98	(30) 1.19	(200) 7.92	(657)26.02

[a] Distance in Kilometres from the Grand Forks.

[b] Life History Stage: F - Fry
Juv - Juvenile
Ad - Adult

APPENDIX I, TABLE 8

RECORD OF OBSERVATIONS OF DIURNAL MOVEMENTS OF MOUNTAIN WHITEFISH IN THE OLDMAN RIVER, AUGUST 27-28, 1985
STUDY SEGMENT 4

Date	Time Period	Duration (h)	Number of Individuals Observed			TOTAL
			Moving Upstream Total (Juv/Ad)[a]	Moving Downstream Total (Juv/Ad)	Non-migrating Total	
Aug 26	1600-1830	2.5			104	104
Aug 27	0600-0700	1.00	12(0/12)	50(25/25)		62
	0700-0810	1.20		324(81/243)		324
	0845-1008	1.40		10(0/10)	18	28
	1116-1200	0.70	9(0/9)		17	26
	1200-1300	1.00	13(0/13)	703(262/441)		716
	1300-1400	1.00	228(84/144)	758(340/418)		986
	1400-1500	1.00	28(14/14)	18(0/18)		46
	1500-1600	1.00		10(4/6)		10
	1600-1700	1.00	225(68/157)	18(5/13)		243
	1700-1800	1.00	336(180/156)	1(0/1)		337
	1800-1900	1.00	252(62/190)			252
	1900-2000	1.00	173(24/149)	2(0/2)		175
	2000-2045	0.75	114(0/114)			114
TOTAL		15.55	1 390(432/958)	1 894(717/1177)	139	3 423

[a] Life History Stage: Juv - Juvenile
Ad - Adult

APPENDIX I, TABLE 9

RECORD OF KICK SAMPLING IN THE OLDMAN RIVER STUDY AREA, OCTOBER, 1985

Kick Sample Station	Segment Location	Date	Total Area Sampled (m^2)	No. Mountain Whitefish Eggs	COMMENTS
KS1	5 - area roughly in the middle of segment	Oct 16	4.65	7	- sampled site where running-ripe Mountain whitefish adults were collected while boat shocking - mainly cobble substrate
KS2	as above	Oct 16	2.32	0	- as above
KS3	as above	Oct 16	1.15	6	- as above
KS4	as above	Oct 16	0.93	5	- as above
KS5	6 - riffle/run sequence immediately below proposed dam site	Oct 17	2.42	24	- as above
KS6	6 - second riffle area below proposed dam site	Oct 17	2.23	0	- sampled in the fast water in the riffle itself
KS7	6 - bottom of preceding riffle	Oct 17	1.67	2	- sampled quieter water near shore at the bottom of riffle
KS8	6 - run below preceding riffle	Oct 17	0.93	4	- quiet, deeper area with gravel-cobble substrate
KS9	as above	Oct 17	0.59	0	- shallow run with gravel-cobble substrate
KS10	6 - next riffle in sequence	Oct 17	1.49	0	- sampled calmer area of riffle where adults were collected

continued ....

APPENDIX I, TABLE 9 (continued)

Kick Sample Station	Segment Location	Date	Total Area Sampled (m^2)	No. Mountain Whitefish Eggs	COMMENTS
KS11	6 - long run below preceeding riffle	Oct 17	3.35	8	sampled cobble-gravel shore along length of run
KS12	6 - next riffle in sequence	Oct 17	1.86	5	- sampled calm water alongside riffle where adult collected
KS13	6 - side channel beside preceding riffle	Oct 17	0.93	0	- sampled calm backwater in side channel - silt over gravel substrate
KS14	6 - run immediately above Reach 6	Oct 17	2.79	2	- eggs found at top of run in area below preceding riffle
KS15	6 - riffle at top end of study reach 6	Oct 17	1.77	6	- sampled calm water alongside riffle
KS16	6 - study reach 6	Oct 17	5.39	17	- eggs collected primarily in the upper half of the reach
KS17	6 - riffle at bottom end of study reach 6	Oct 17	5.67	0	- sampled in riffle and in calm areas alongside riffle
KS18	6 - bottom of reach 6 downstream to old bridge pilings	Oct 17	11.81	8	- sampled cobble-gravel shoreline along right downstream bank
KS19	6 - left downstream bank from bridge pilings to site GN5	Oct 18	3.35	17	- egg collection sites somewhat concentrated near old bridge pilings
KS20	6 - right downstream bank from old bridge to site GN5	Oct 18	5.58	5	
KS21	6 - area between site GN5 and first riffle downstream	Oct 18	4.09	0	- sampled run area before the riffle and top of riffle - except areas of bedrock substrate

APPENDIX I, TABLE 9 (continued)

Kick Sample Station	Segment Location	Date	Total Area Sampled (m^2)	No. Mountain Whitefish Eggs	COMMENTS
KS22	6 - first riffle below site GN5	Oct 18	6.04	8	- sampled calm water along the edges of main riffle where adults collected
KS23	6 - downstream of preceding riffle to coulee	Oct 18	6.04	18	- mainly sampled shallower water along right downstream bank - mainly cobble substrate
KS24	6 - run from coulee downstream to island	Oct 18	3.35	4	- sampled mid-stream and along right bank to avoid deep water and bedrock along left side
KS25	6 - run from island to riffle above study reach 6	Oct 18	3.91	23	- sampled along right downstream bank and in mid-stream
KS26	6 - run from island to riffle above study reach 6	Oct 18	4.65	7	- sampled along left downstream bank
KS27	6 - riffle above study reach 5 to top end of reach 5	Oct 18	6.51	7	- eggs collected in upstream section of riffle only - left downstream bank
KS28	6 - riffle above study reach 5, right downstream bank	Oct 18	5.11	4	- eggs collected from cobble-gravel area
KS29	5 - study reach 5, left downstream bank	Oct 18	3.72	0	- substrate loose gravel-cobble in deep water
KS30	5 - bottom half of study reach 5, right bank	Oct 18	4.09	0	- sampled along both sides of large gravel bar island in middle of reach
KS31	5 - riffle at bottom end of study reach 5	Oct 18	3.72	0	- sampled fast water at the top end of the riffle

continued ...

APPENDIX I, TABLE 9 (continued)

Kick Sample Station	Segment Location	Date	Total Area Sampled (m^2)	No. Mountain Whitefish Eggs	COMMENTS
KS32	5 - run between preceding riffle and pool at Summerview Bridge	Oct 18	8.93	51	- 41 of 51 eggs collected from along left downstream bank
KS33	5 - Summerview Bridge	Oct 18	1.86	0	- sampled along right downstream bank in shallows at bridge pilings
KS34	5 - first riffle downstream of Summer Bridge	Oct 22	3.35	32	- sampled gravel substrate along left downstream bank
KS35	5 - confluence with Pincher Creek	Oct 22	2.42	6	- sampled top of riffle below pool where ripe adults were collected
KS36	5 - first site below Pincher Creek	Oct 22	1.77	1	- large amounts of algae covering substrate
KS37	5 - 200 m downstream of previous site	Oct 22	0.28	3	- gravel-coble substrate
KS38	5 - first riffle downstream of large oxbow	Oct 22	0.74	2	- sampled in riffle where running-ripe adult captured by electrofisher
KS39	5 - second riffle below large oxbow	Oct 22	0.93	1	- as above
KS40	5 - next downstream site	Oct 22	1.21	0	- substrate mostly small-medium gravel covered by silt and algae
KS41	as above	Oct 22	1.58	0	- sampled in the riffle and along the cobble cutbank
KS42	as above	Oct 22	0.46	4	- sampled shallow run immediately above small riffle

continued ...

APPENDIX I, TABLE 9 (concluded)

Kick Sample Station	Segment Location	Date	Total Area Sampled (m^2)	No. Mountain Whitefish Eggs	COMMENTS
KS43	4 - run immediately below LNID headworks	Oct 23	3.16	0	- clay-gravel-cobble substrate
KS44	4 - bottom of large island below LNID headworks	Oct 23	3.25	0	- clean gravel substrate but very loose and unstable
KS45	4 - first riffle	Oct 23	3.25	0	- as above
KS46	4 - first cliffs below LNID headworks	Oct 23	3.25	2	- sampled along left downstream bank
KS47	4 - second cliffs below LNID headworks	Oct 23	1.86	1	- cobble-gravel-clay substrate
KS48	4 - first site where adults collected below LNID	Oct 23	5.11	0	
KS49	4 - second site where adults collected below LNID	Oct 23	4.84	0	
KS50	4 - island downstream of LNID aqueduct	Oct 23	6.97	2	- clean gravel substrate - site where adults previously collected
KS51	4 - next downstream site where adults collected	Oct 23	4.65	1	- large cobble substrate
KS52	as above	Oct 23	1.49	1	- riffle with cobble-gravel substrate
TOTAL			173.47	294	

APPENDIX I, TABLE 10

CATEGORIES OF LIFE HISTORY ANALYSIS VARIABLES AND STOMACH CONTENTS

Variable	Categories
Life Stages	Adult, fry, juvenile, unknown
Sex	Female, male, unknown
Maturity	Green - will spawn this year but gonads are not fully developed
	Non-Spawner - mature fish which will not spawn during the next spawning season
	Ripe - gonads are fully developed but gametes are not released with slight pressure on the abdomen
	Running Ripe - gametes are released by slight pressure on the abdomen
	Spawned out - spent
Stomach Contents	Fish remains, invertebrate remains, empty, fish eggs, other

APPENDIX I, TABLE 11

AGING STRUCTURE COLLECTED AND METHODS OF STORAGE

Species	Aging Structure	Storage Methods
Mountain whitefish Lake whitefish Rainbow trout Cutthroat trout Brown trout Dolly varden Mooneye Burbot	scales otoliths	dry in envelope in glycerine in vials
Walleye Sauger	scales dorsal spines	dry in envelope
Northern pike	scales cleithrum	

APPENDIX I, TABLE 12

NUMBERS OF FISH TAGGED IN THE OLDMAN RIVER STUDY AREA, JULY, 1985

Location	Mountain Whitefish	Northern Pike	Walleye	Sauger	Mooneye
Segment 1	4	2	1		
Segment 2	20	1	2		
Segment 3	1	1	2	1	1
Segment 5	7				
TOTAL	32	4	5	1	1

APPENDIX I, TABLE 13

MEASUREMENTS OF MEAN DIAMETER OF MOUNTAIN WHITEFISH EGGS RECOVERED FROM THE OLDMAN RIVER STUDY AREA, OCTOBER, 1985

Date	Collection Site	Collection Method	No. Eggs Measured	Mean Diameter (mm)
Oct 13	Segment 5-Summerview bridge	Stripped from fish[1]	30	3.40
Oct 13	Segment 5-downstream of Summerview bridge	Stripped from fish	30	3.68
Oct 14	Segment 4-downstream of LNID weir	Stripped from fish	30	3.72
Oct 15	Segment 6-proposed damsite	Stripped from fish #380	30	3.63
Oct 15	Segment 6	Stripped from fish #381	30	3.65
Oct 15	Segment 6-riffle immediately above study reach 5	Kick sample	14	3.55
Oct 16	Segment 5-KS1-4	Kick sample	16	3.71
Oct 17	Segment 6-upper half of segment 6	Kick sample	58	3.77
Oct 18	From middle of segment 6 to Summerview bridge segment 5	Kick sample	122	3.84
Oct 19	Segment 6-proposed damsite	Kick sample	47	3.77
Oct 20	Segment 6-upper half of segment 6	Kick sample	82	3.84
Oct 21	Segment 5-immediately below study reach 5	Kick sample	63	3.74
TOTAL			552	3.69

[1] For eggs stripped from fish, measurements refer to the mean diameter of fertilized, water-hardened eggs.

APPENDIX II

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TABLE II-2 MOUNTAIN WHITEFISH ADULT SPAWNING

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TABLE II-4 MOUNTAIN WHITEFISH JUVENILE FEEDING

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TABLE II-7 RAINBOW TROUT JUVENILE FEEDING

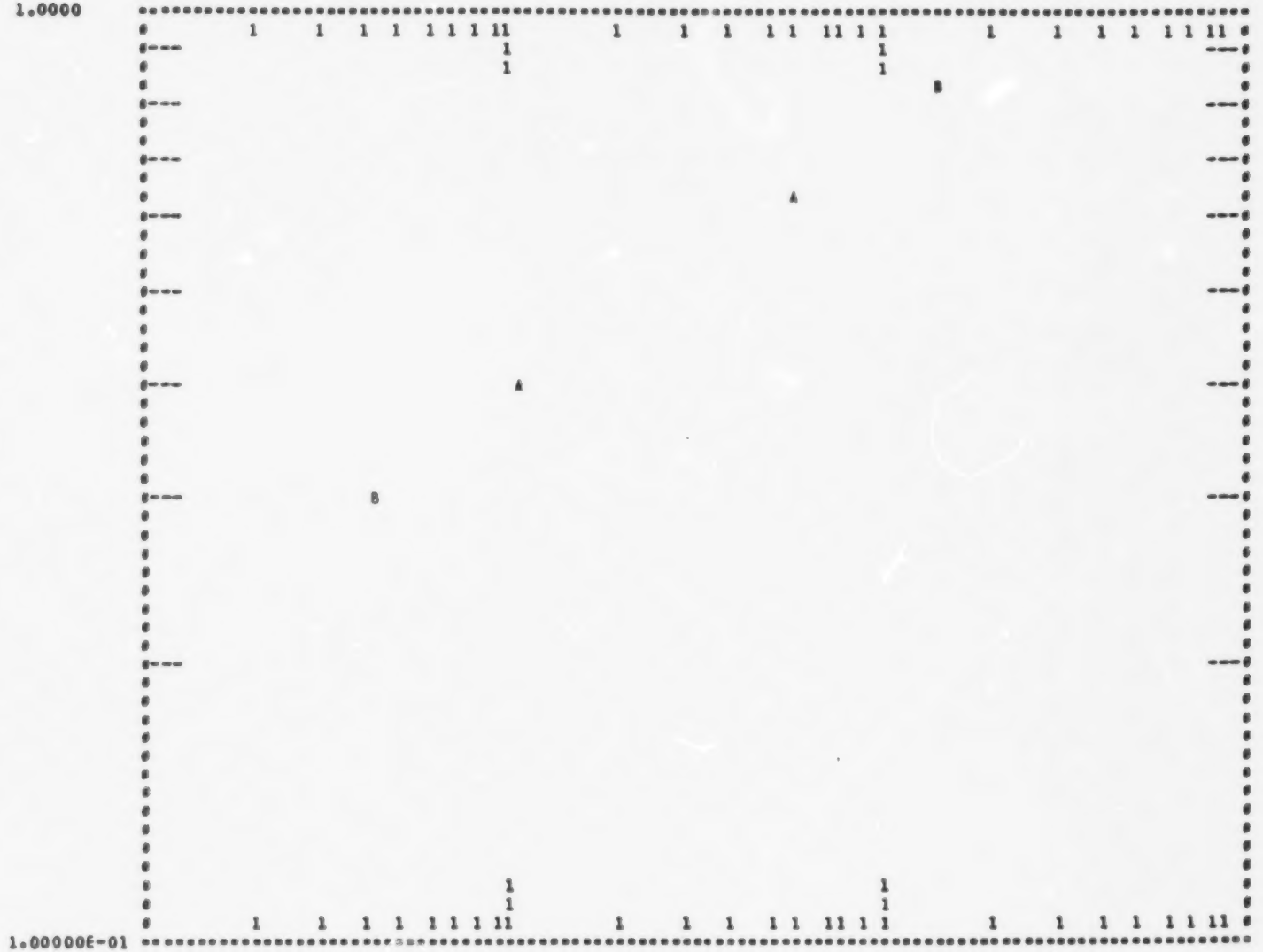
TABLE II-8 NORTHERN PIKE ADULT FEEDING

PART I

STAGE-DISCHARGE RELATIONSHIPS AT STUDY TRANSECTS

The stage-discharge relationship for each study transect is presented in the following section of the report. These relationships have been developed on the basis of only two flows in the study area. The transects in this appendix are identified by two ordinal numbers. For example, cross-section 11.00 denotes study reach 1, cross-section 1, which is the downstream cross-section in that study reach. The graphical relationship are depicted by the letters A and B, with A representing acutal stage-discharge measurements, and B illustrating the extrapolation of the relationship.

GRAPH 1



RATING CURVE FOR CROSS-SECTION 11.00

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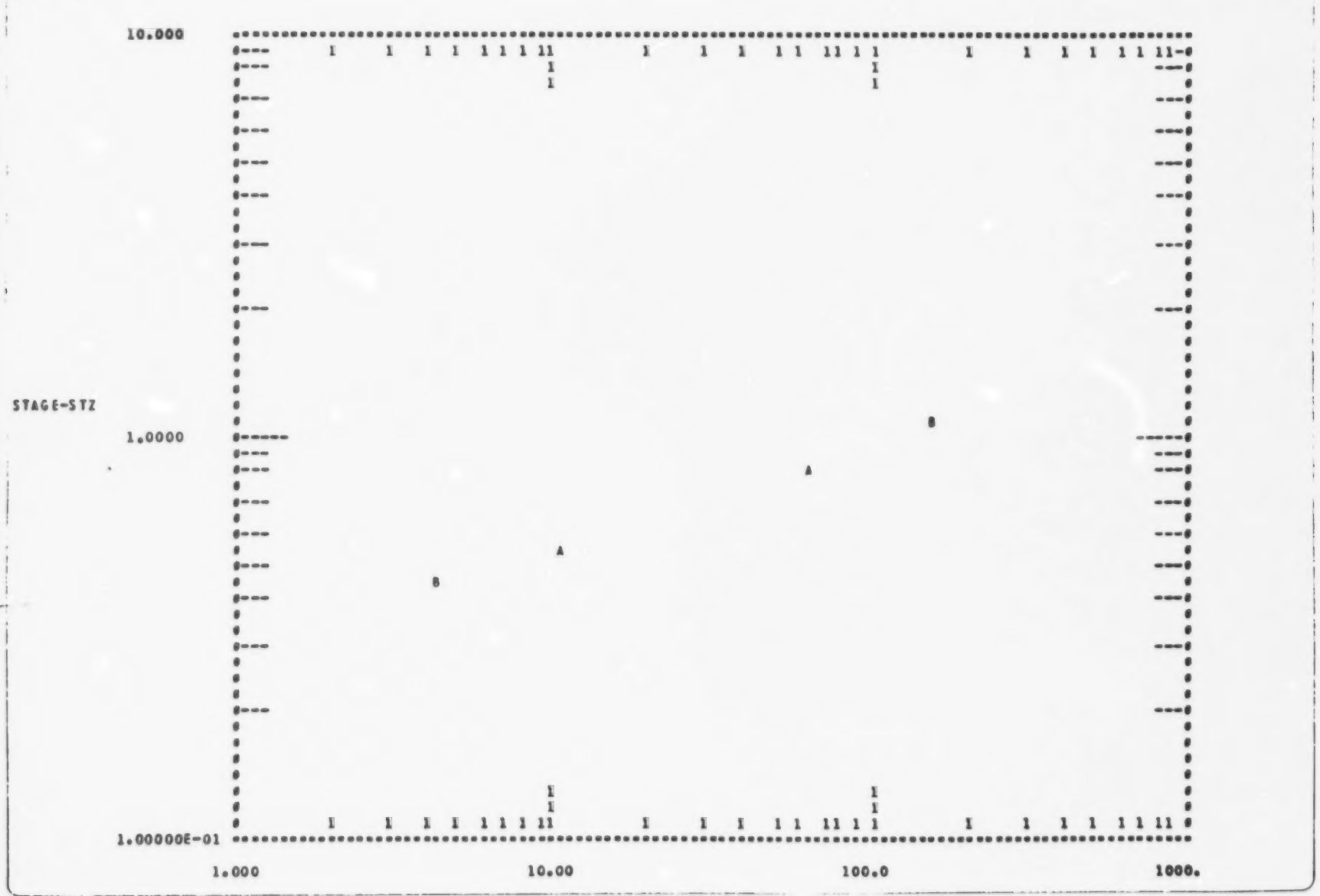
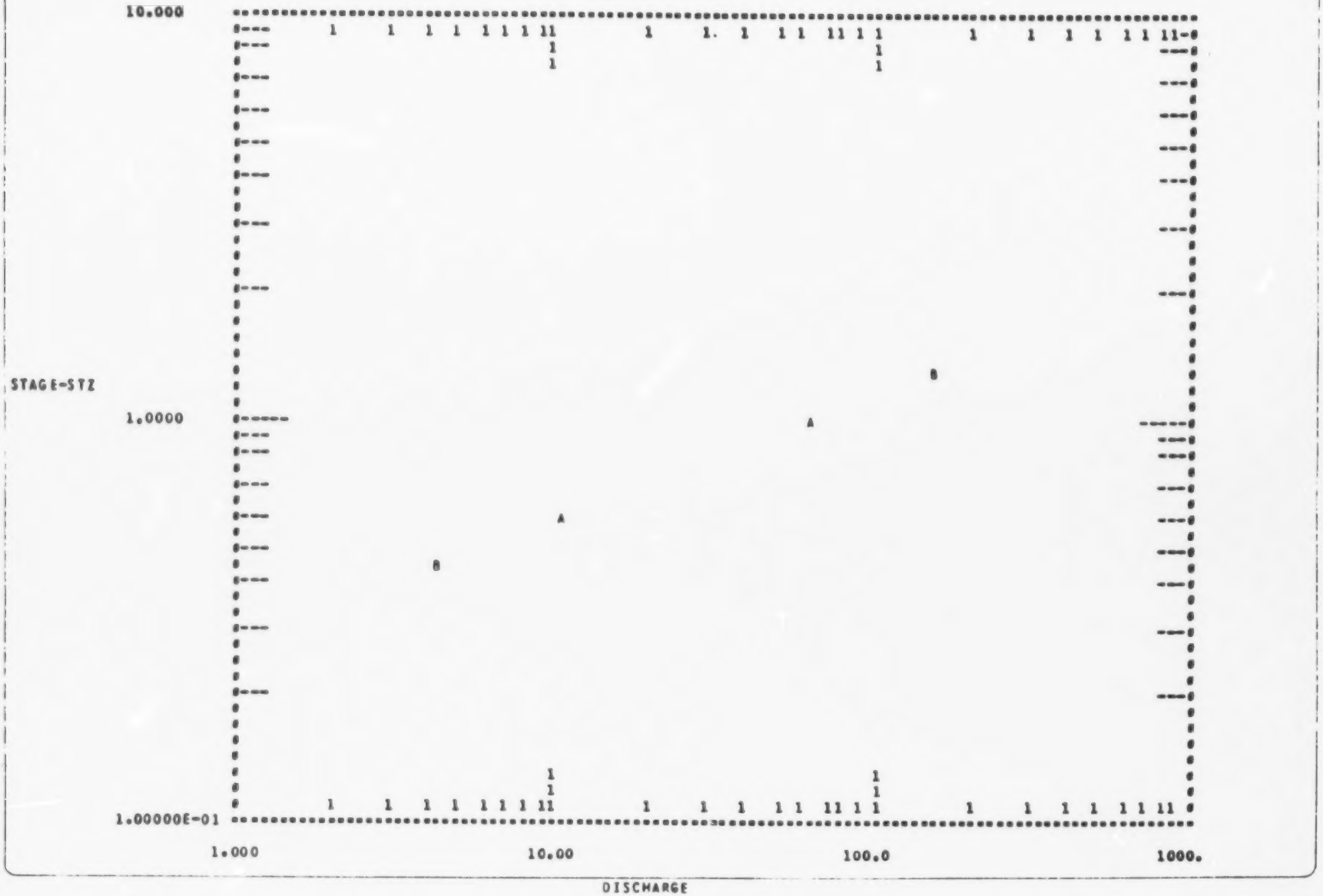


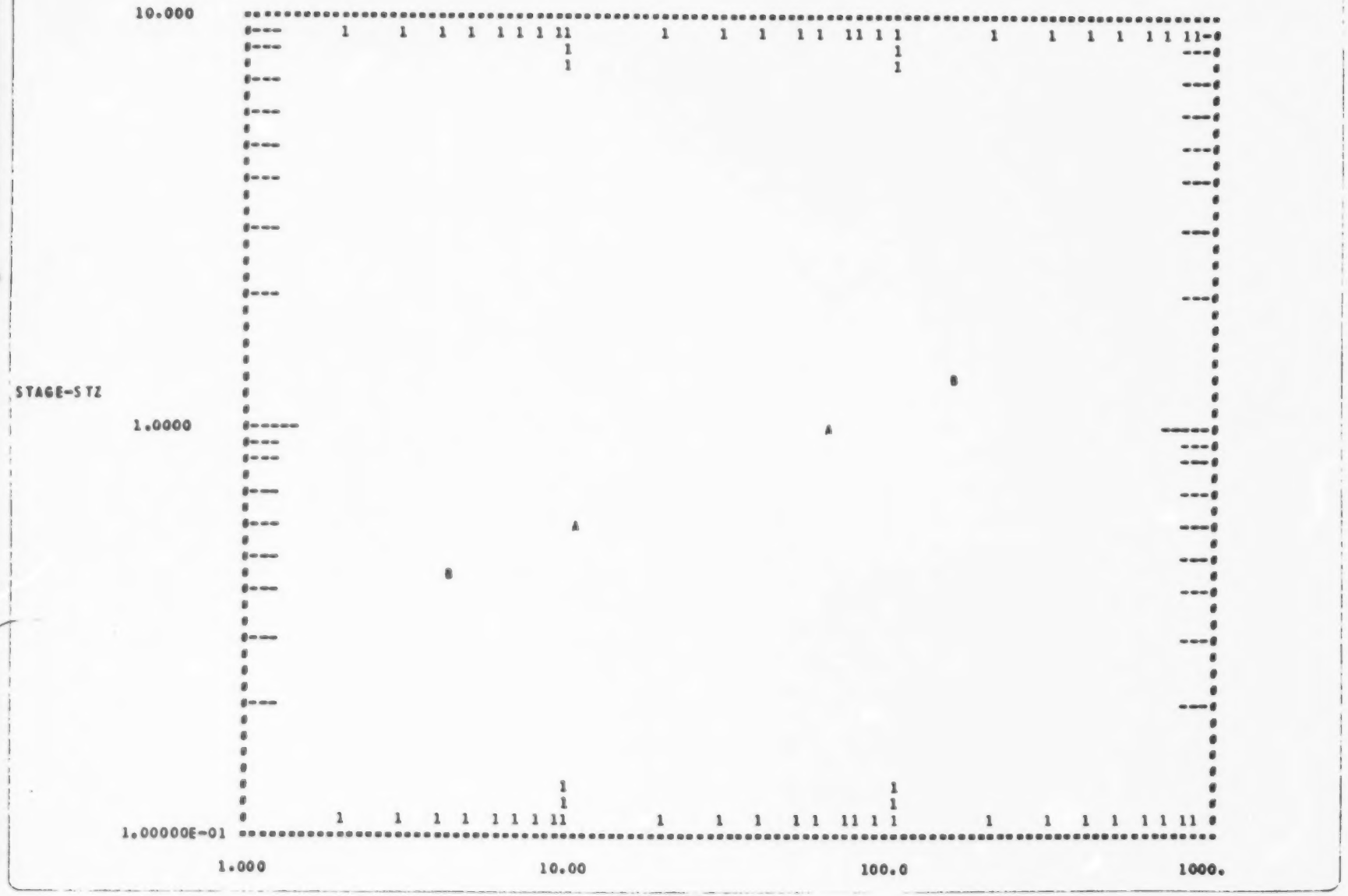
RATING CURVE FOR CROSS-SECTION 12.00

GRAPH 3



RATING CURVE FOR CROSS-SECTION 13.00

GRAPH 4



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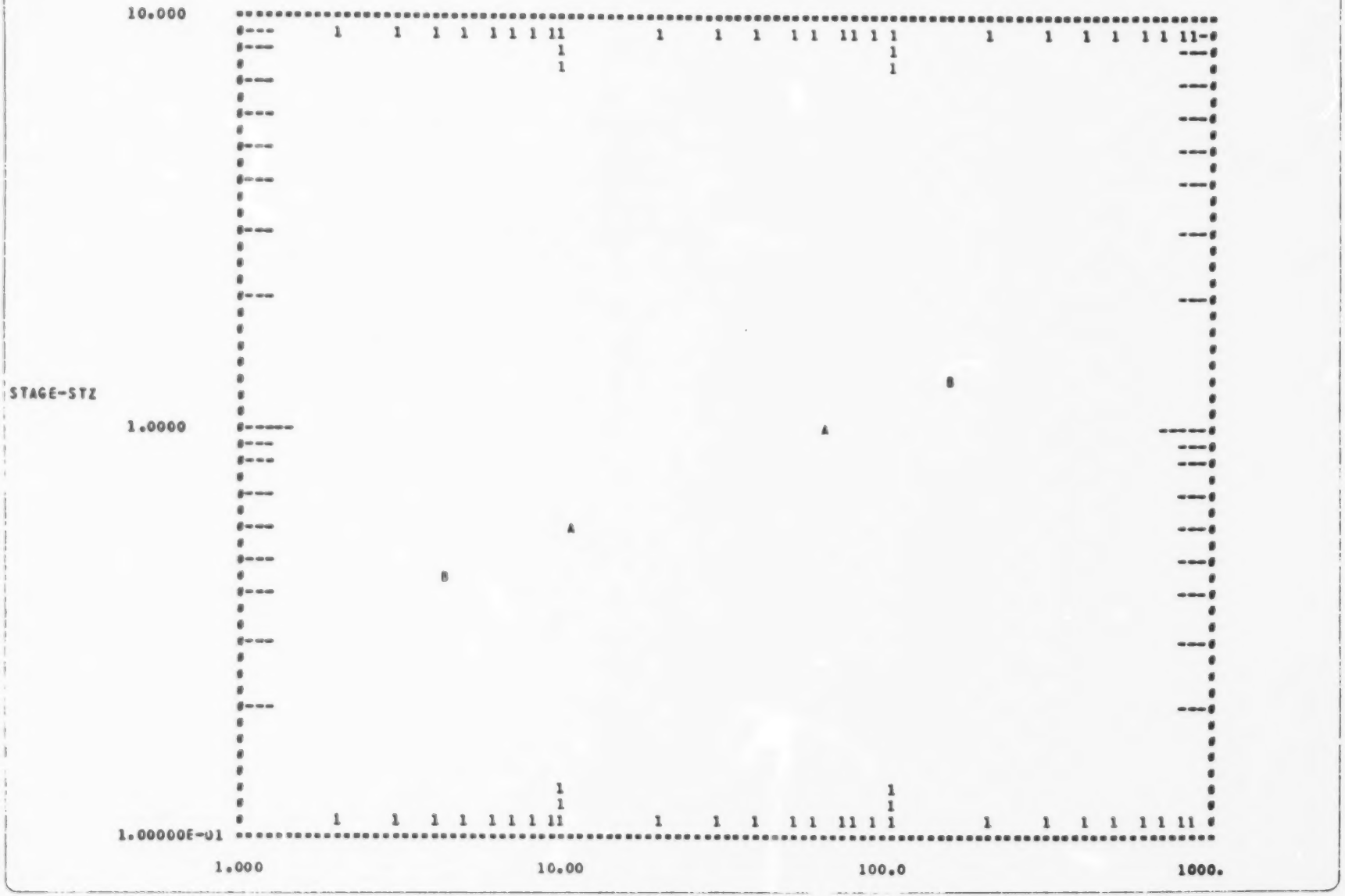

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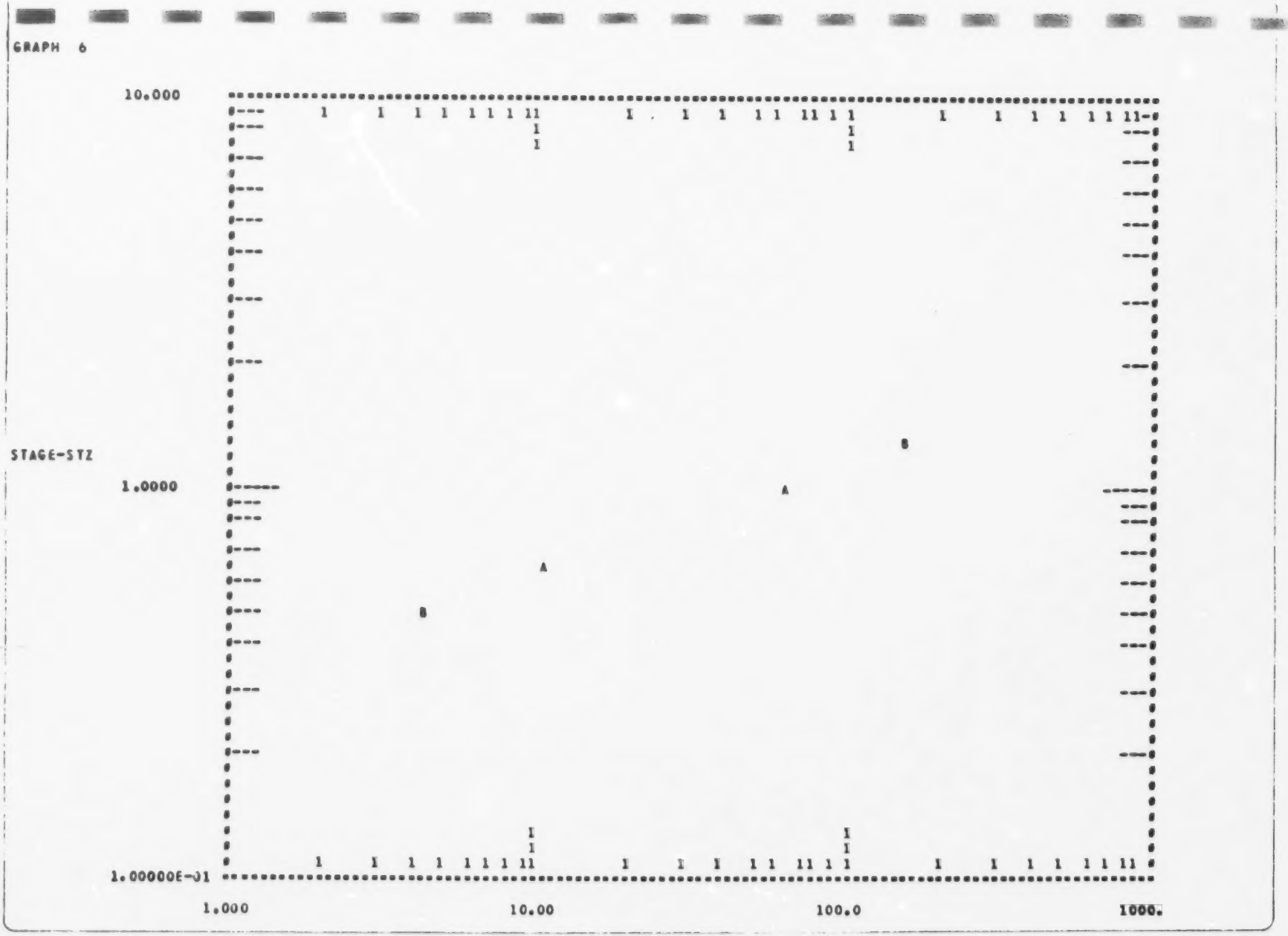

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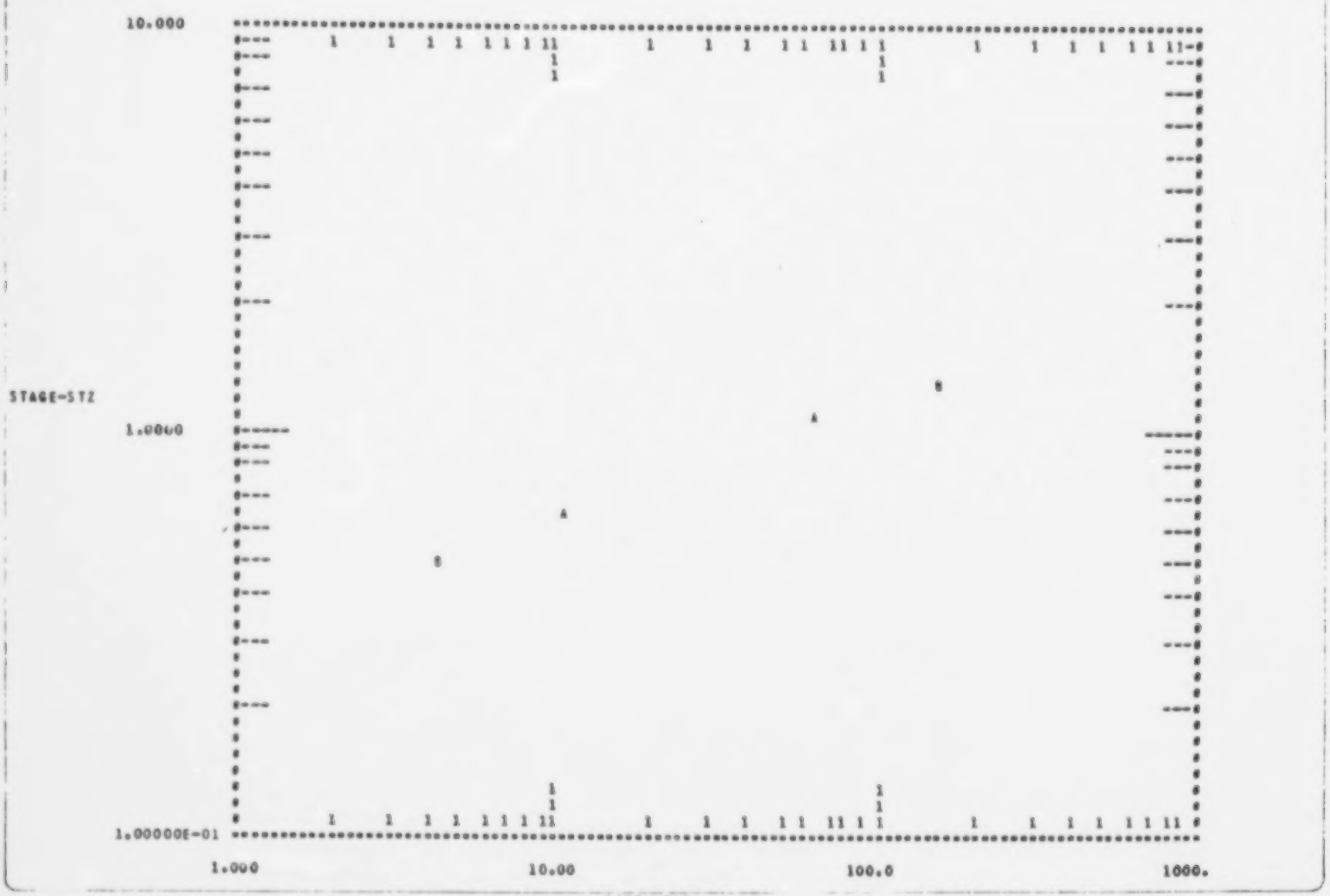

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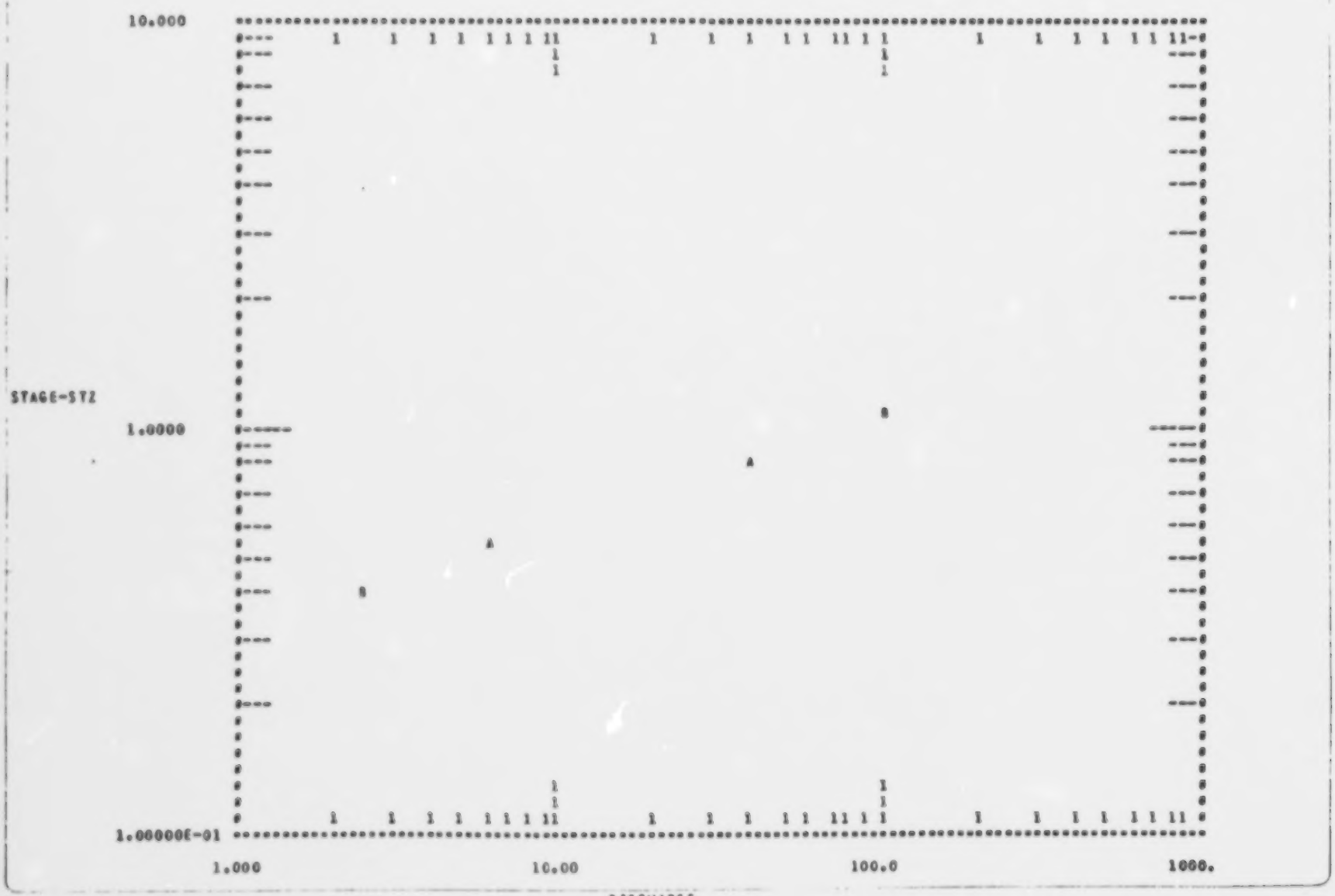

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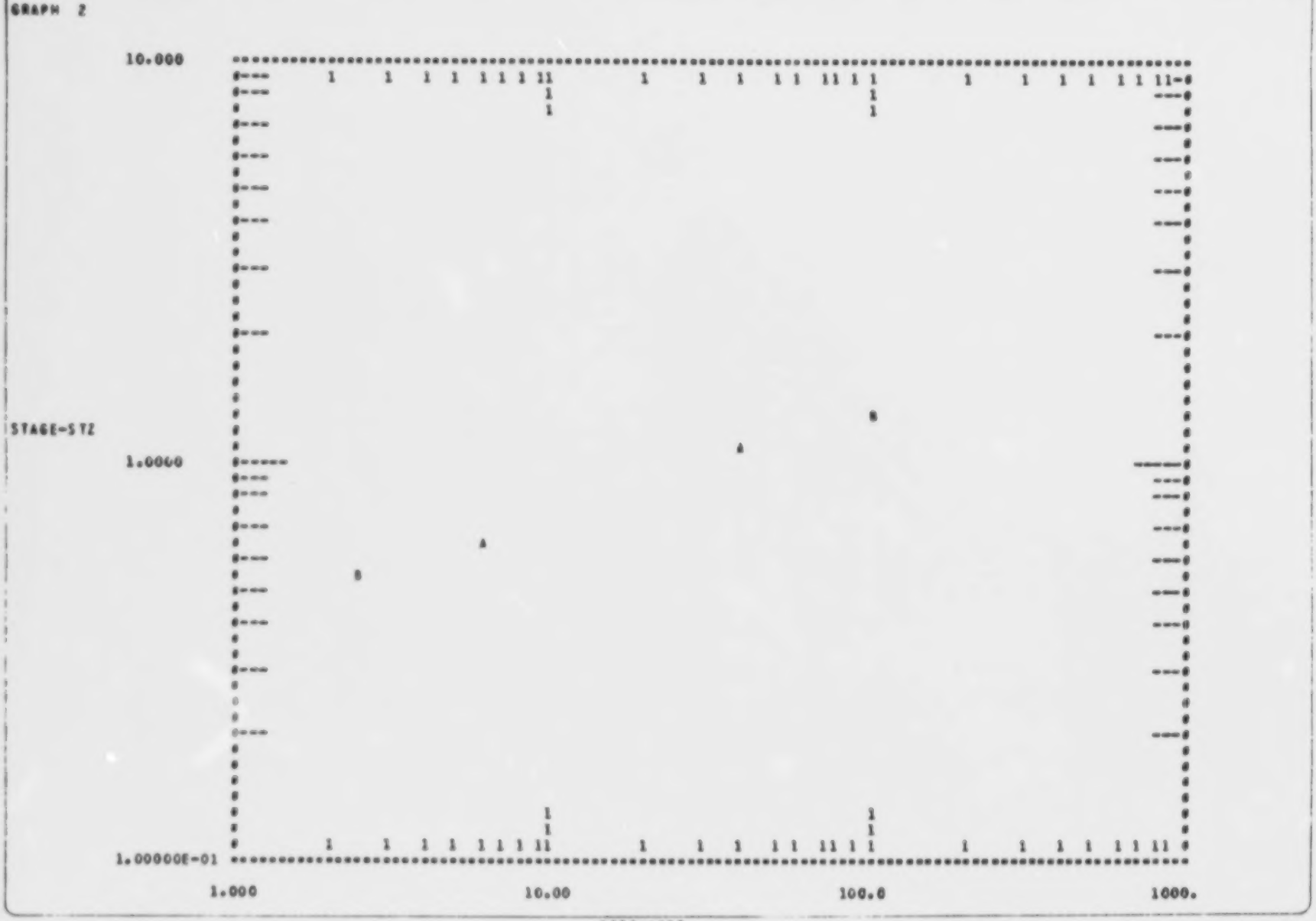

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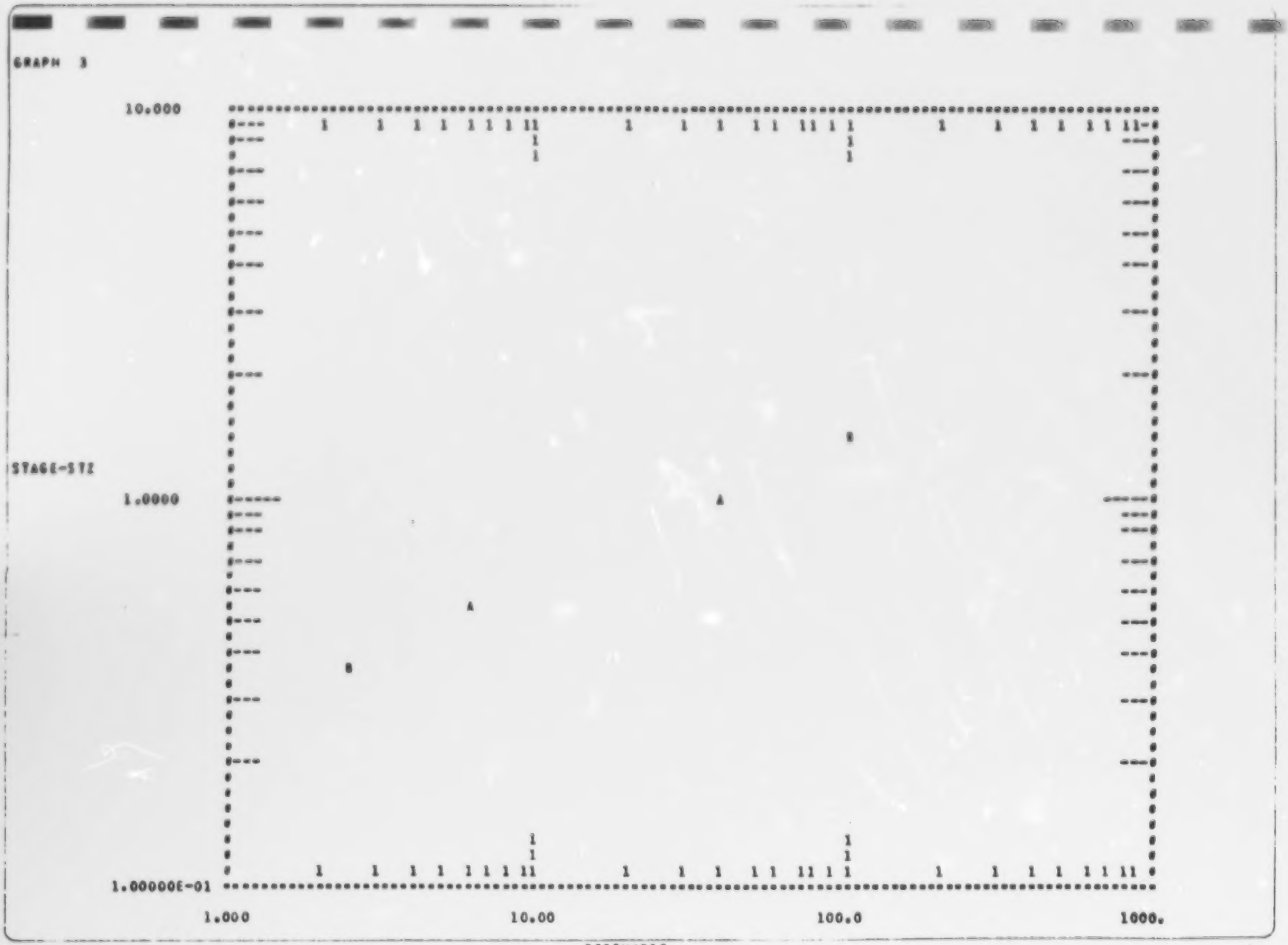

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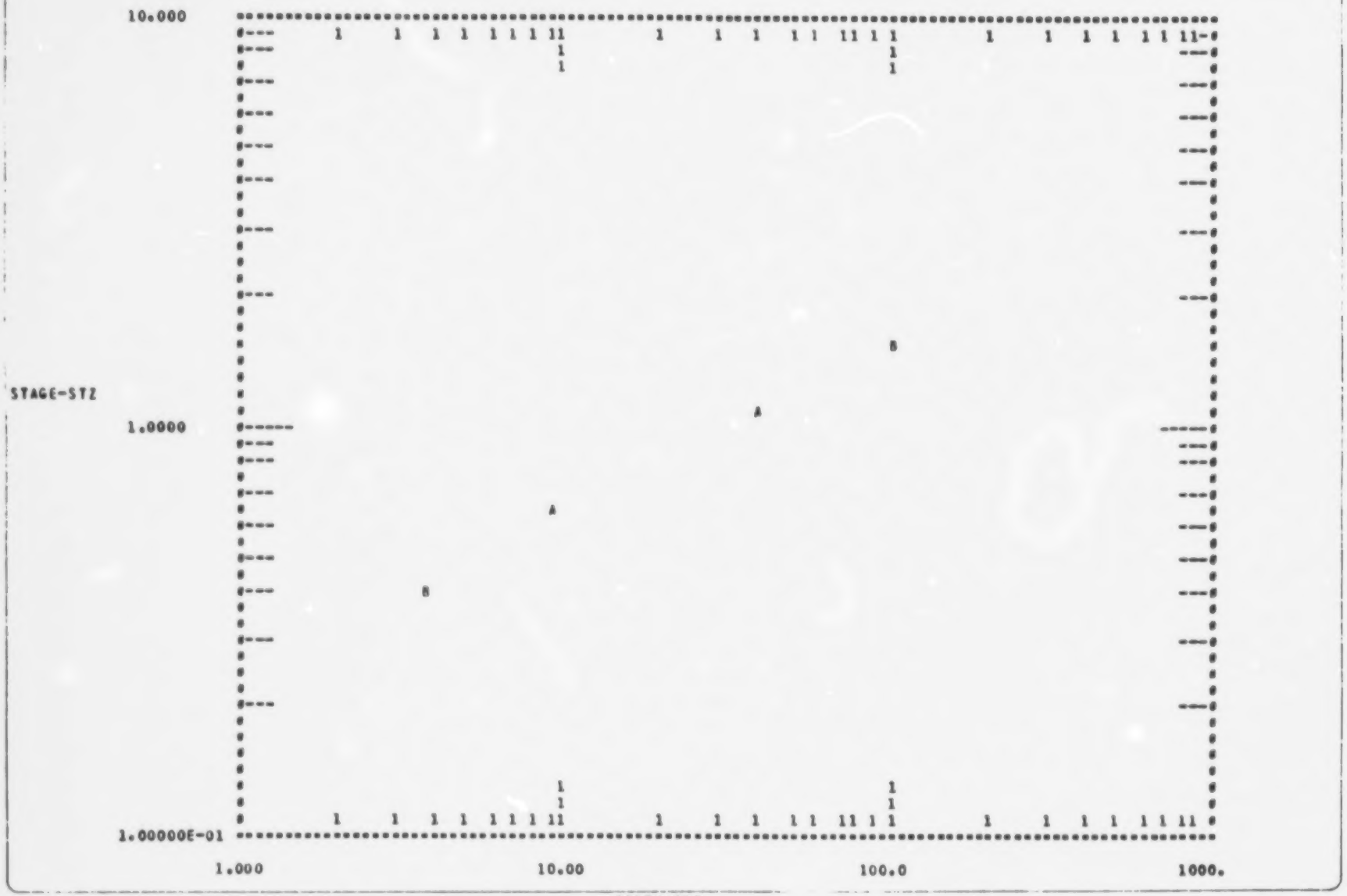

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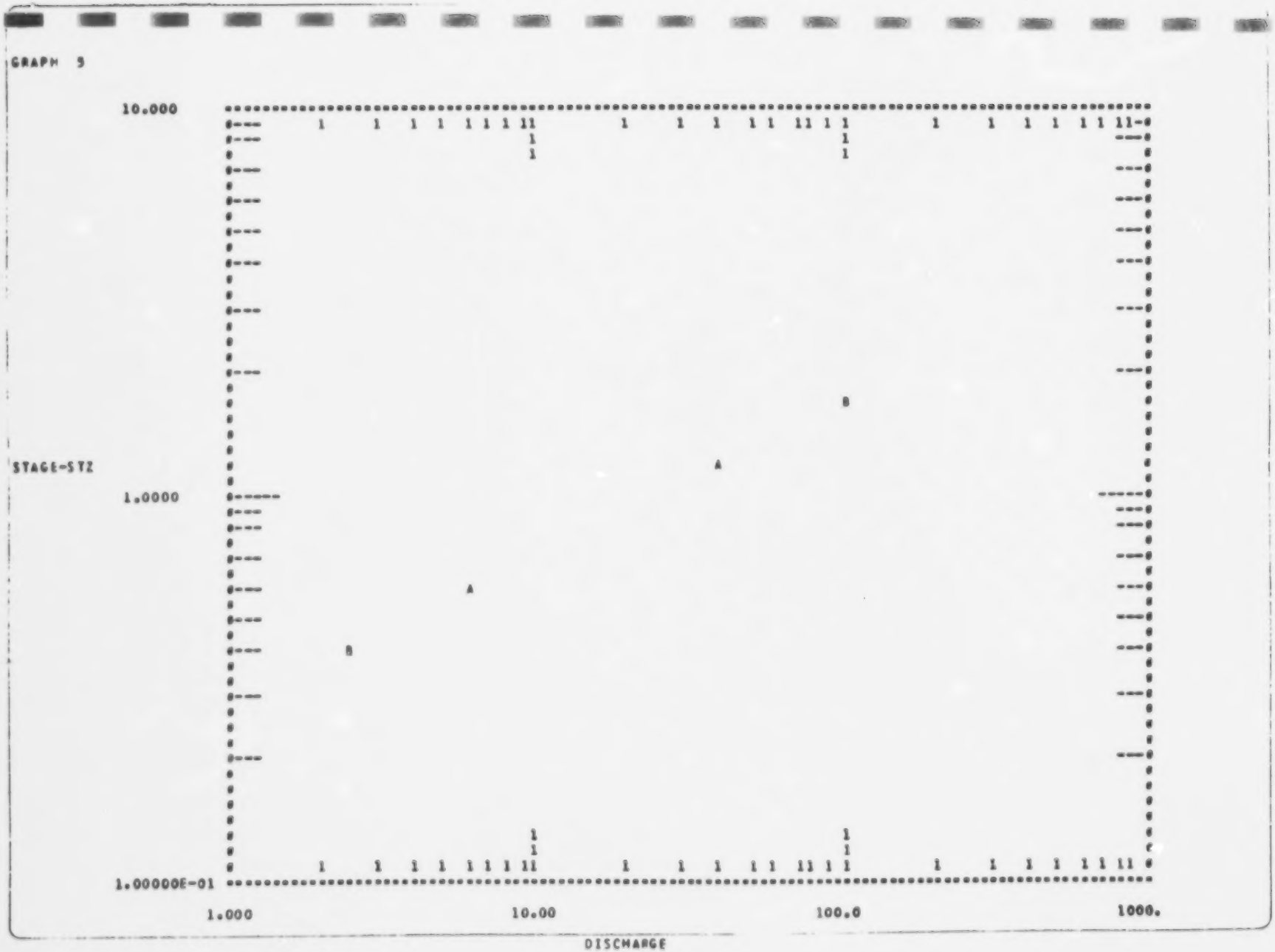

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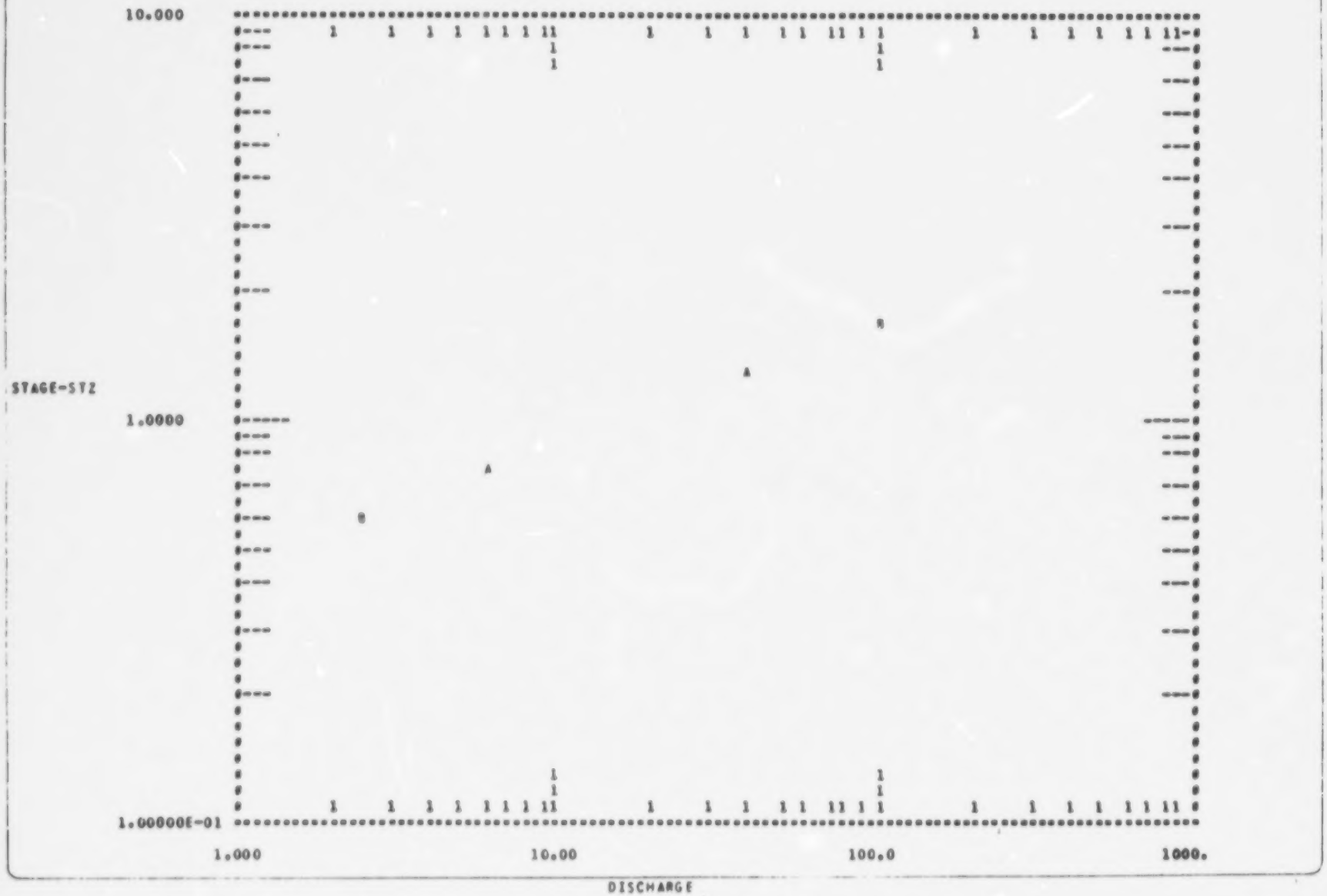

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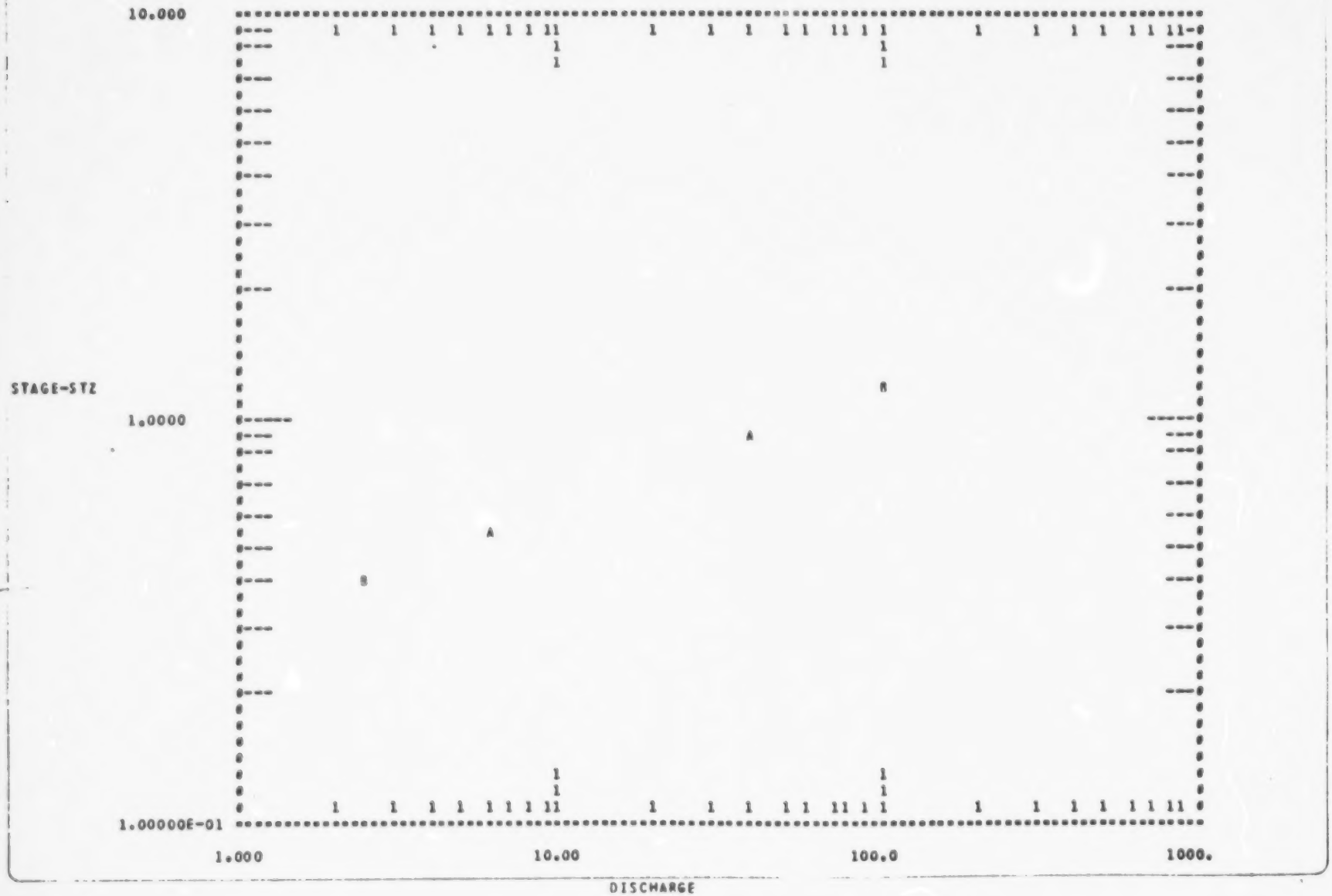

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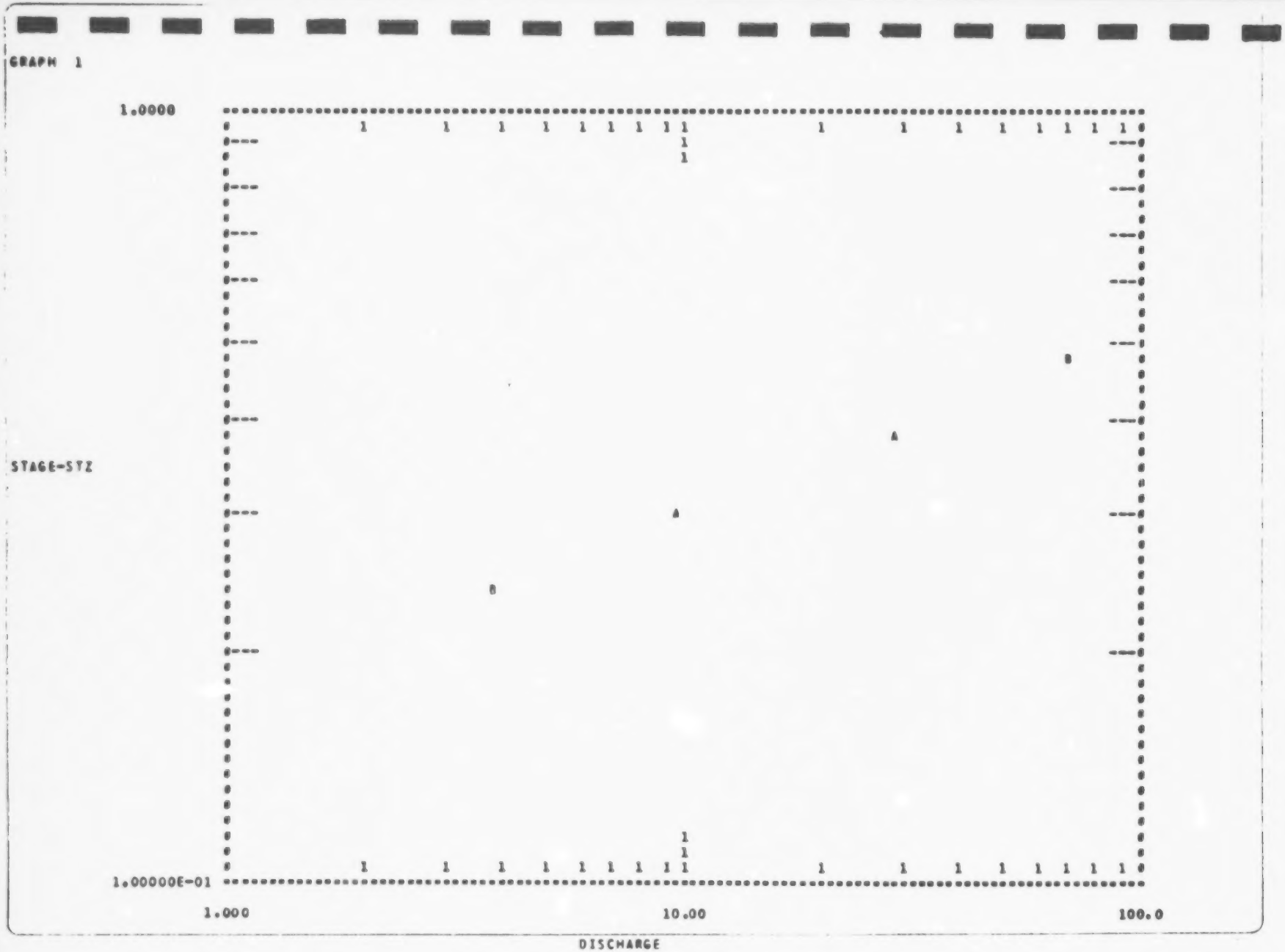

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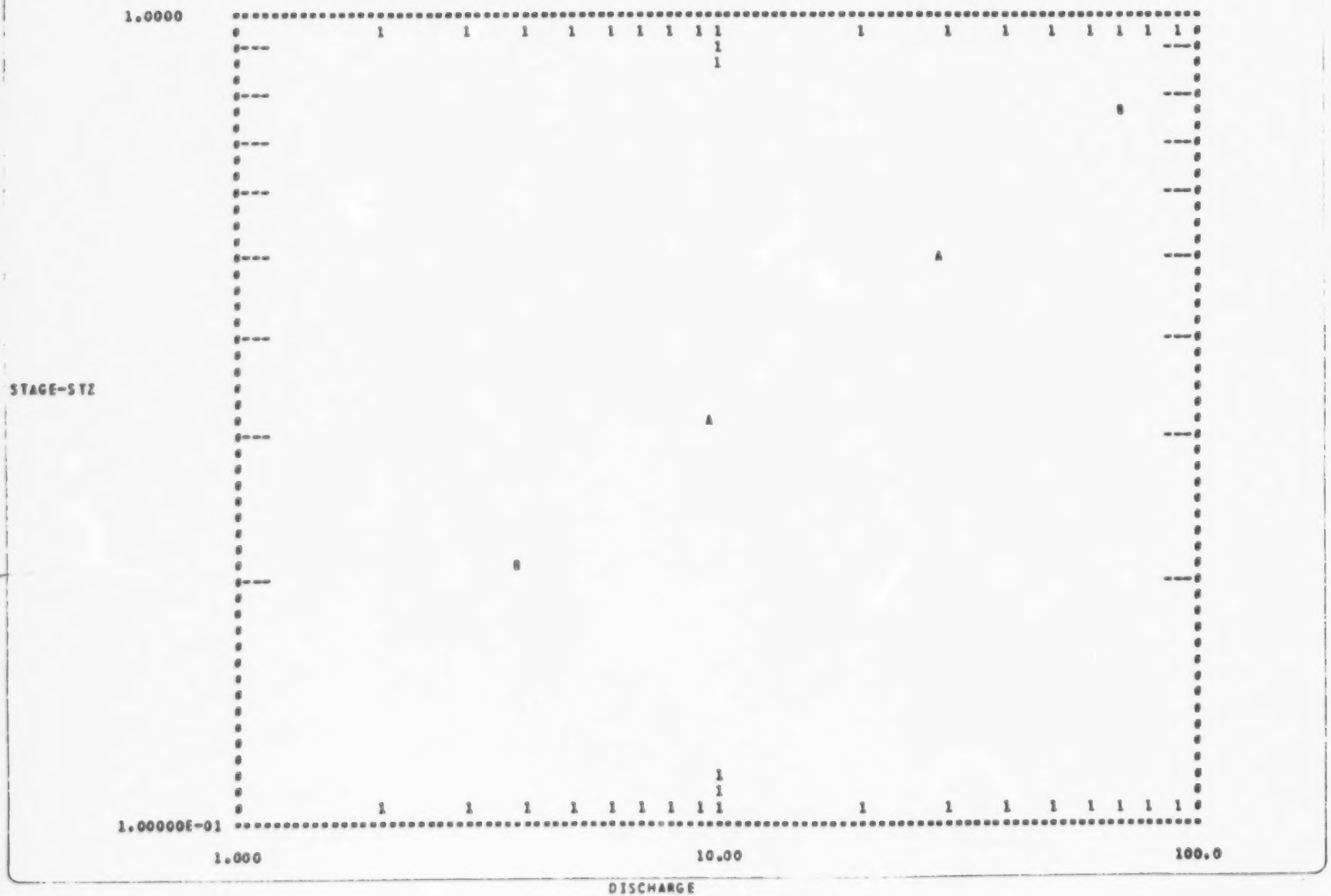

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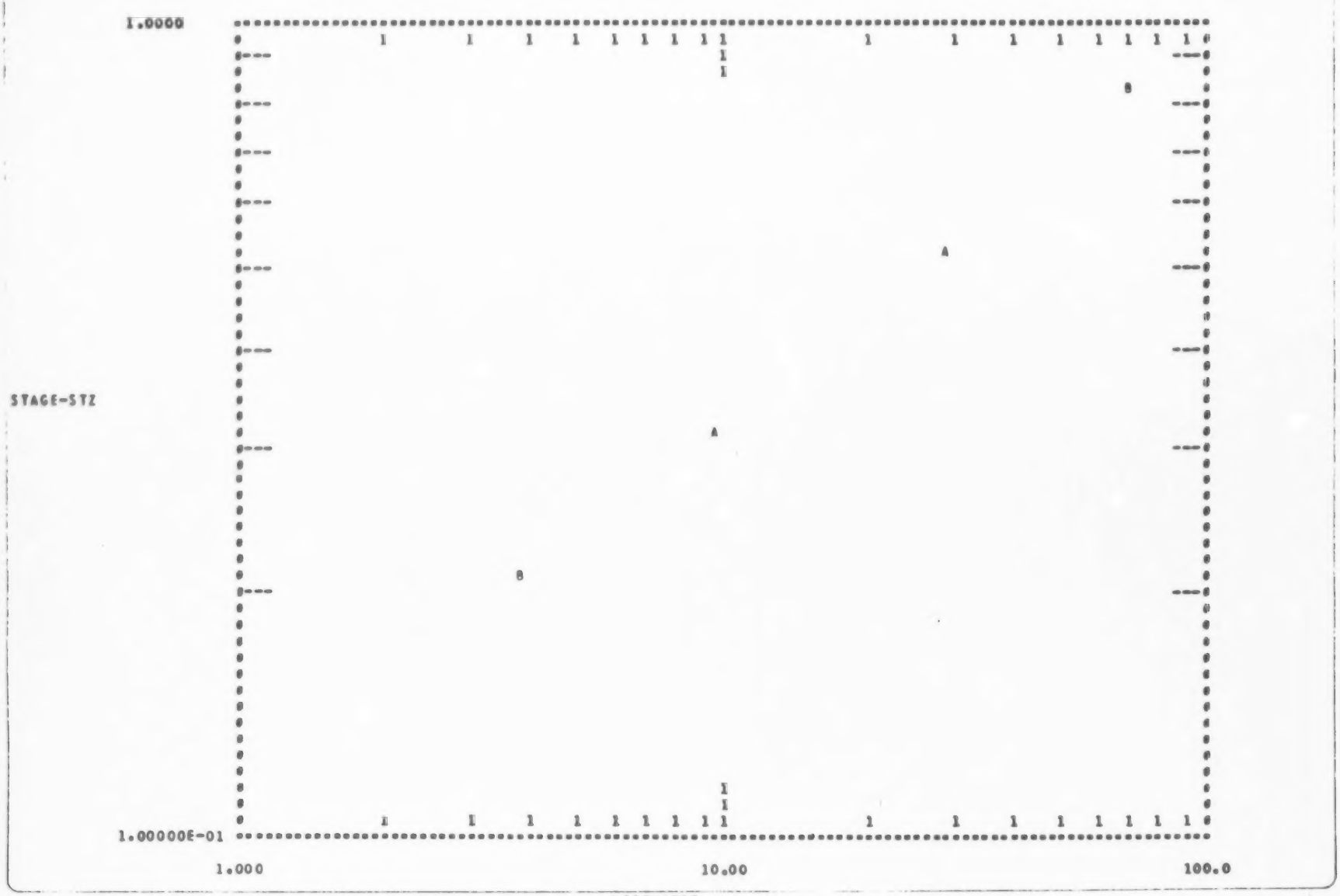

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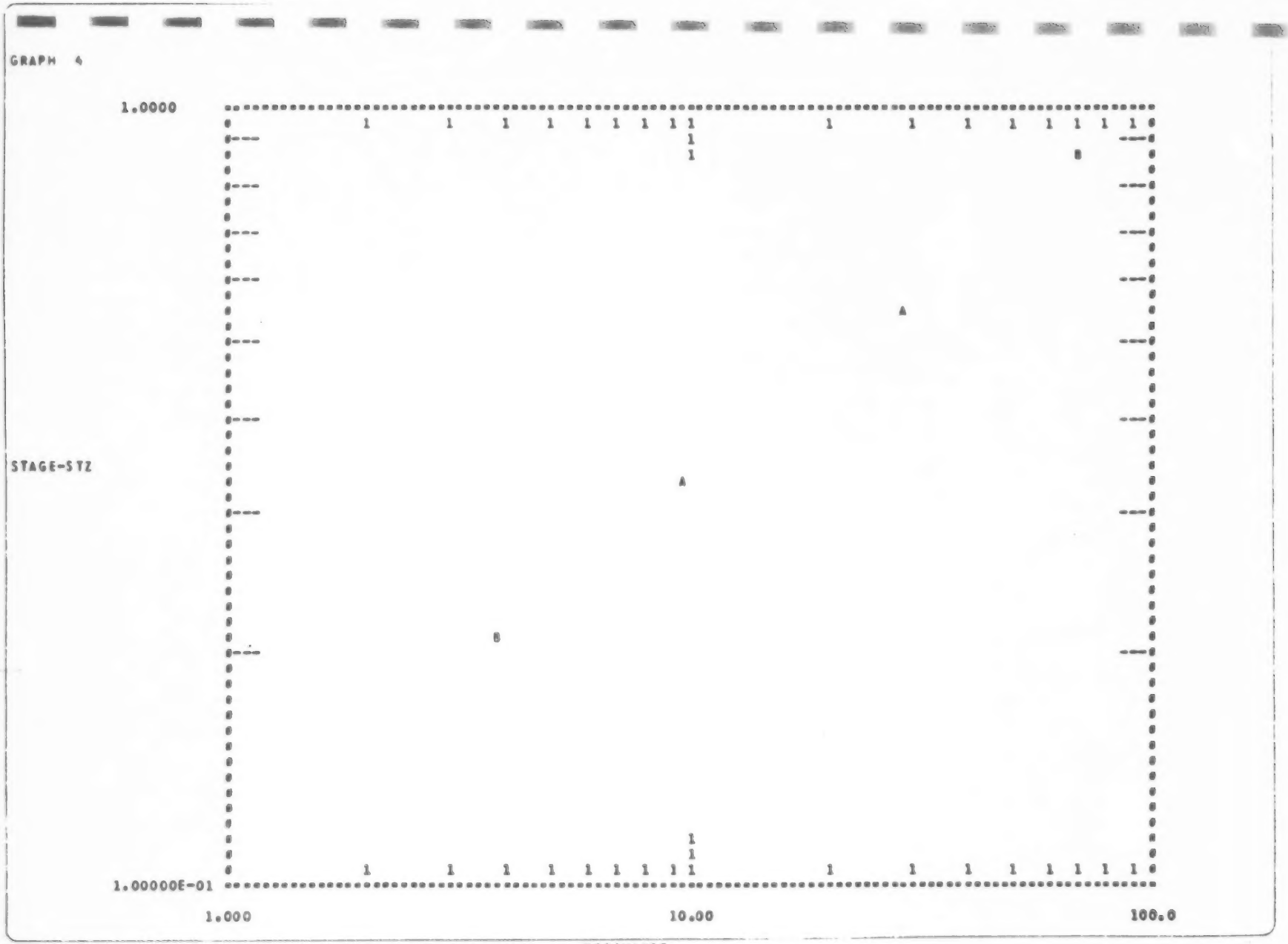

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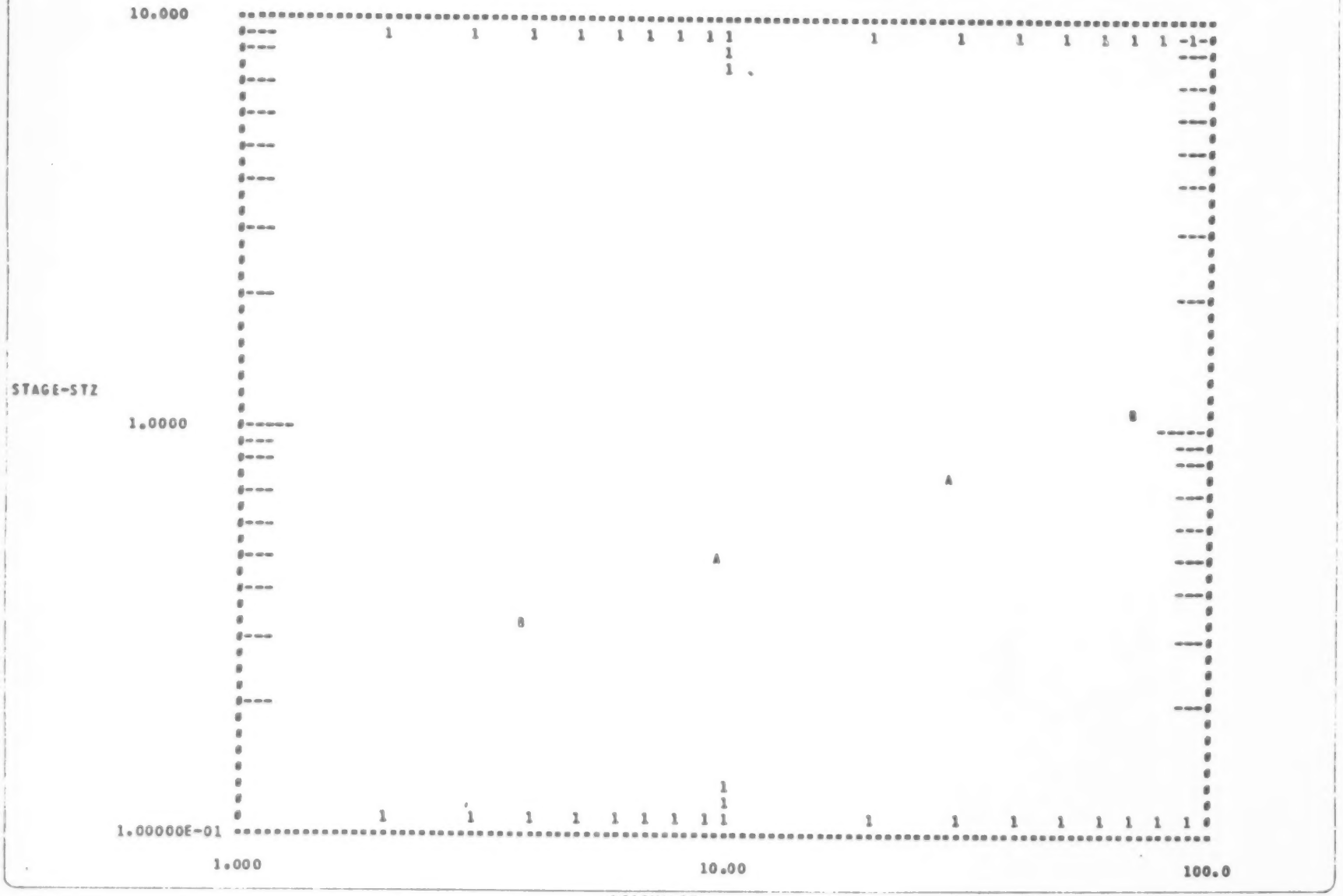

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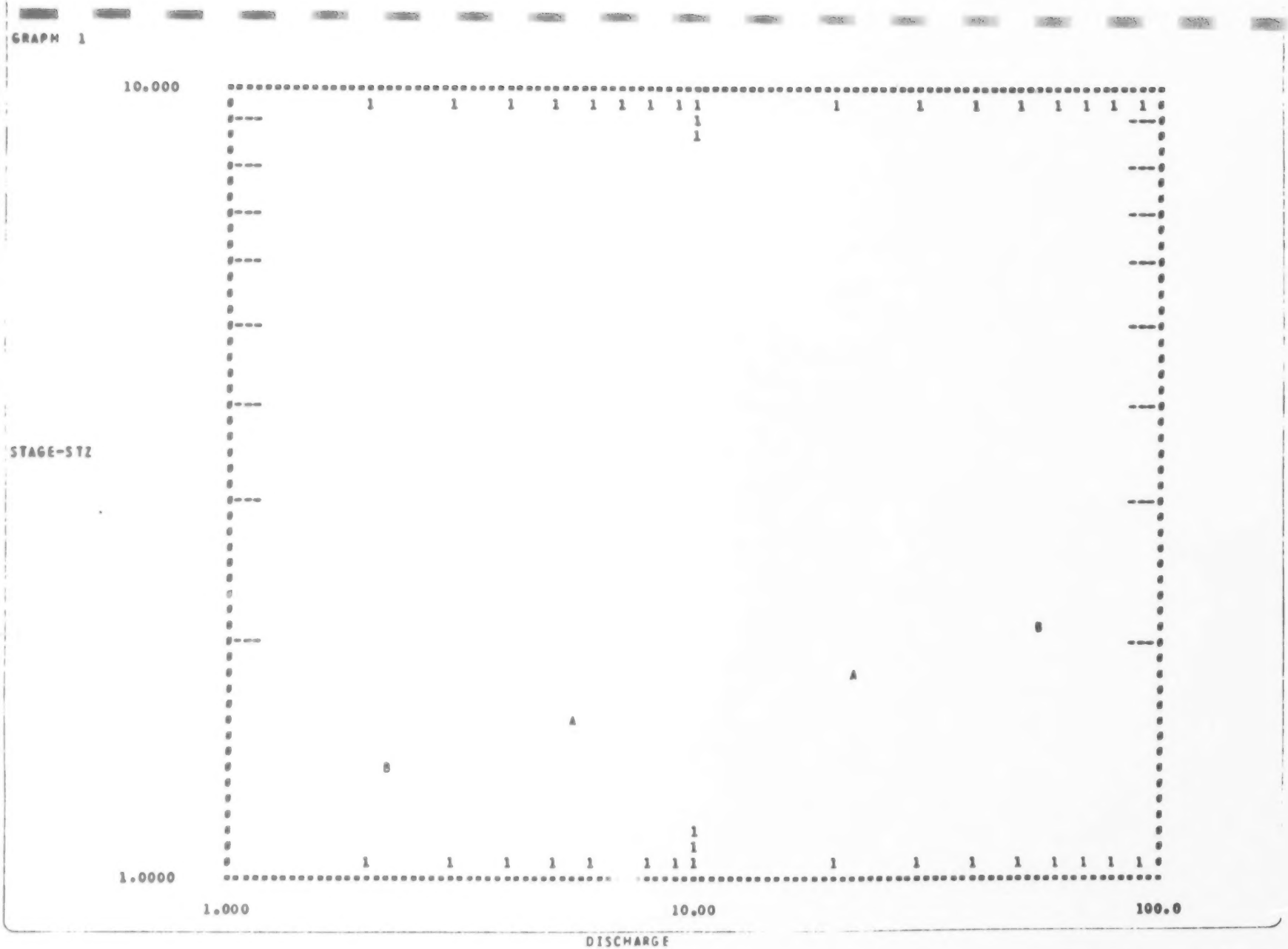

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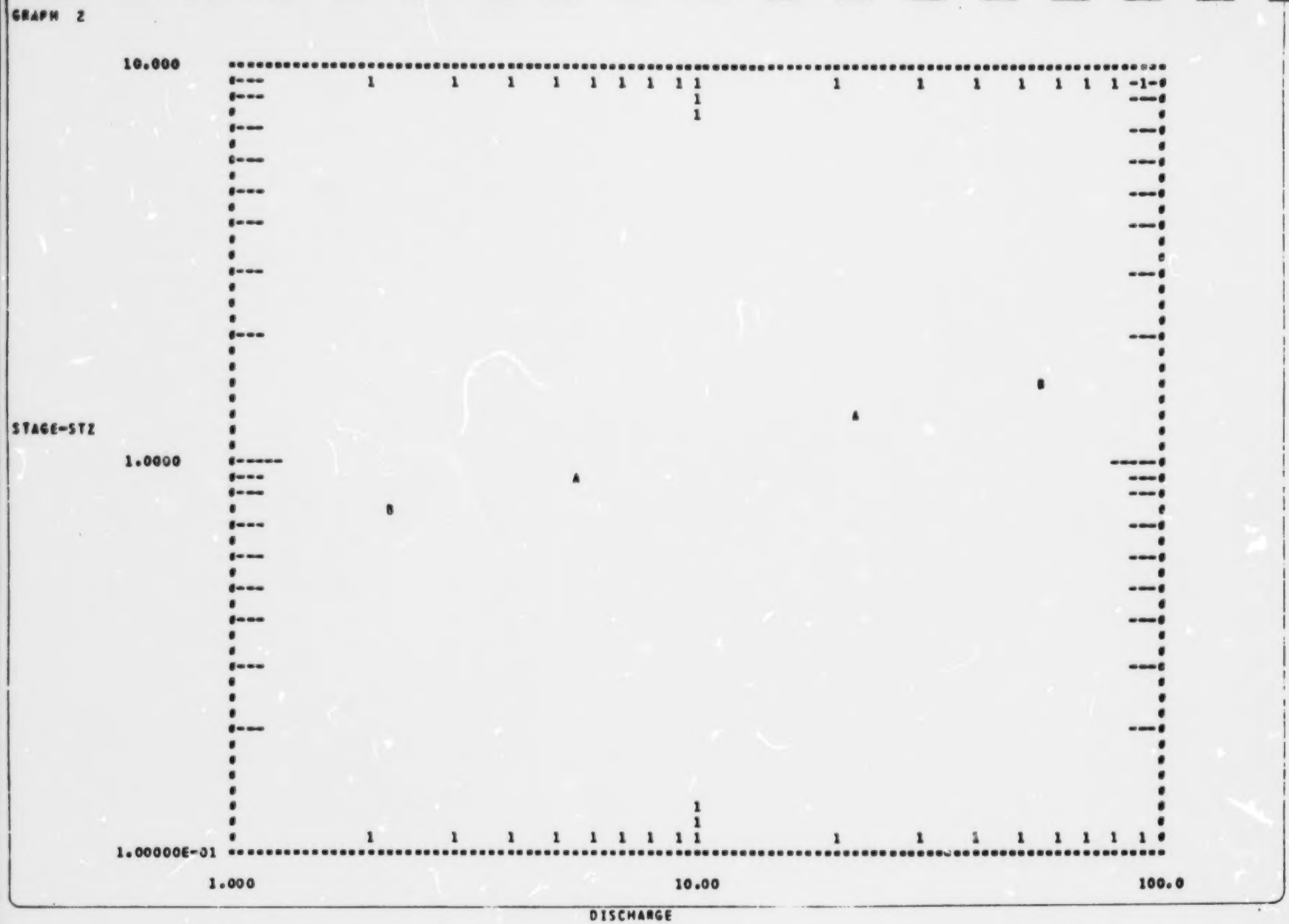

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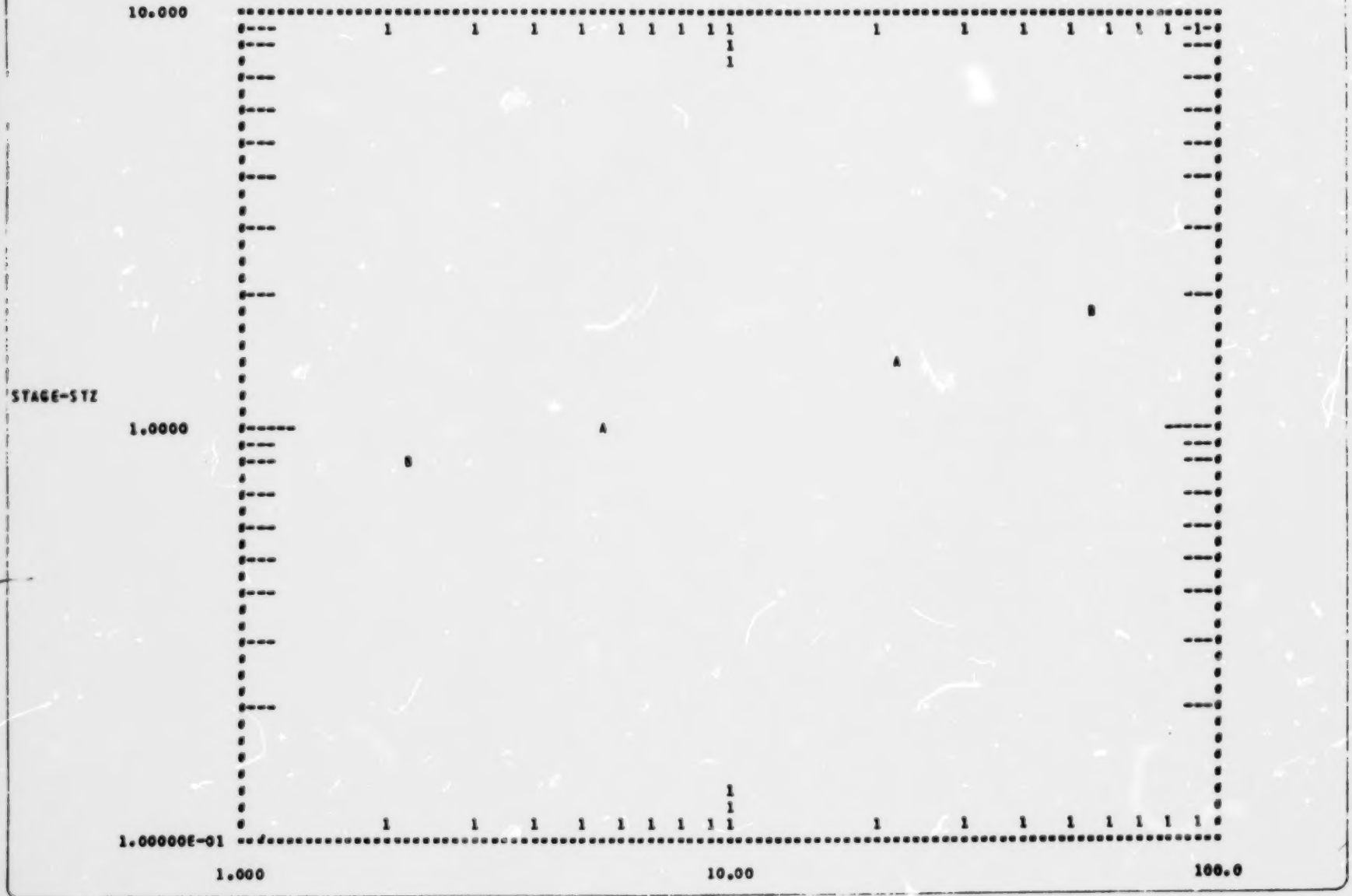

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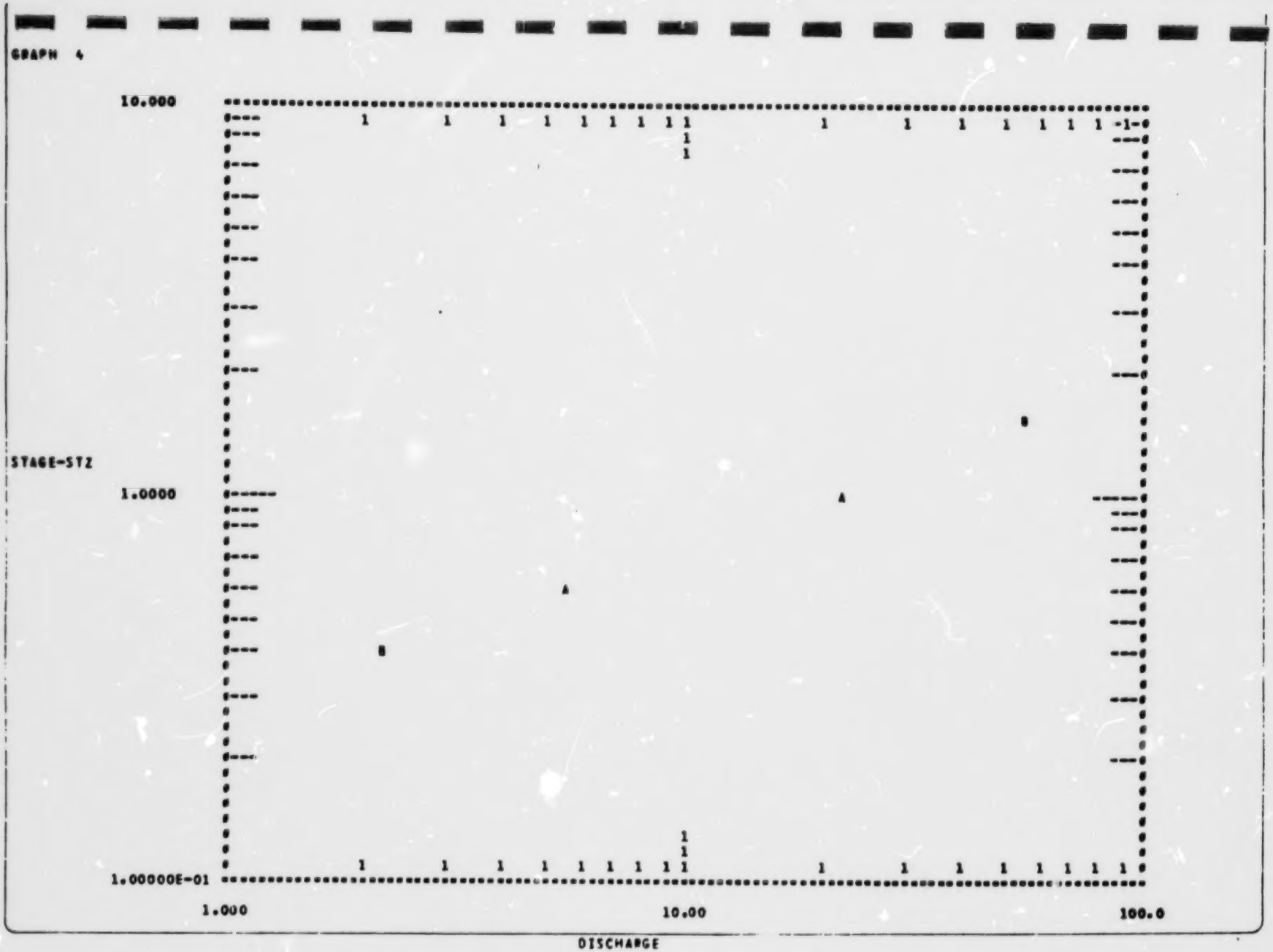

RATING CURVE FOR CROSS-SECTION 44.00

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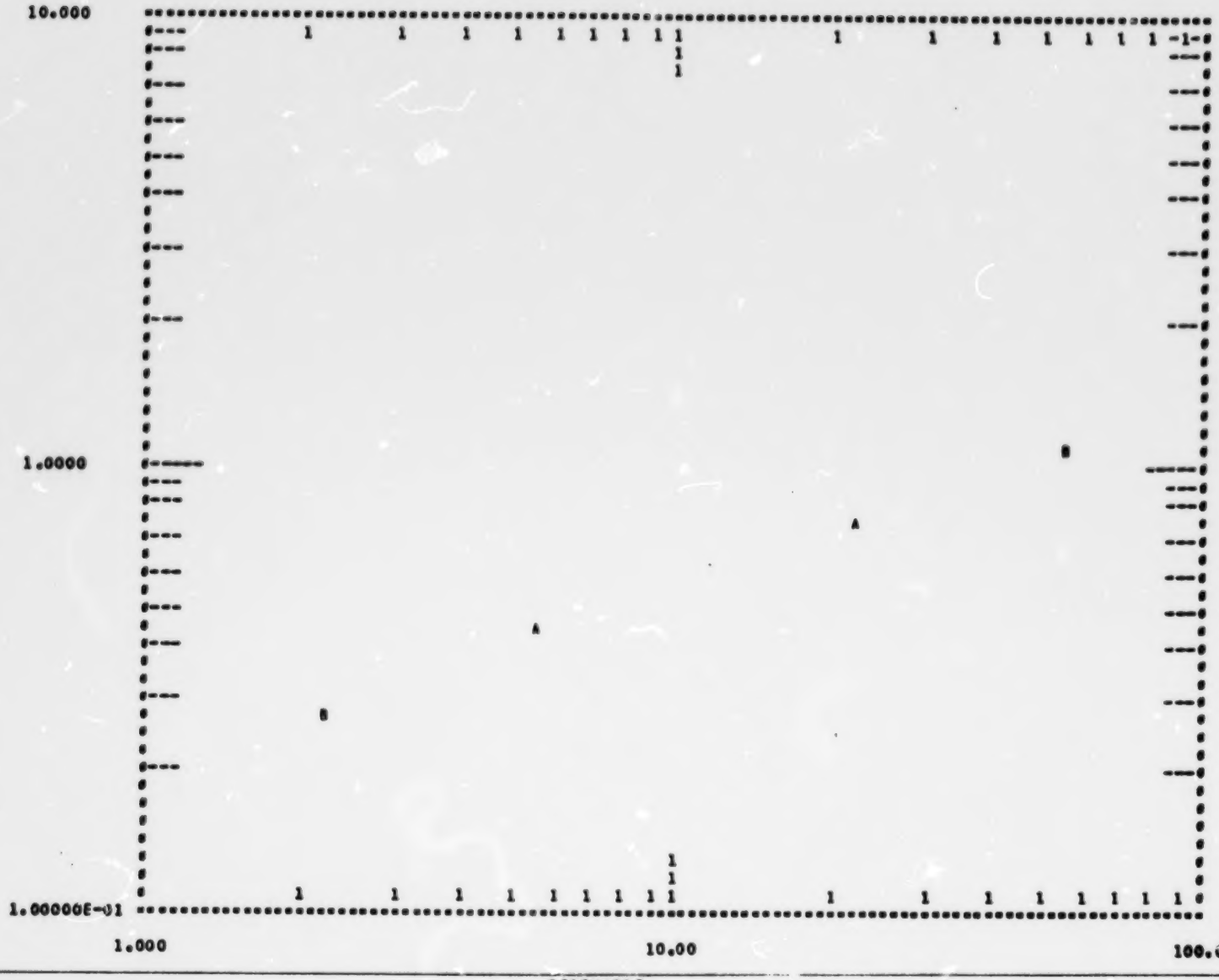

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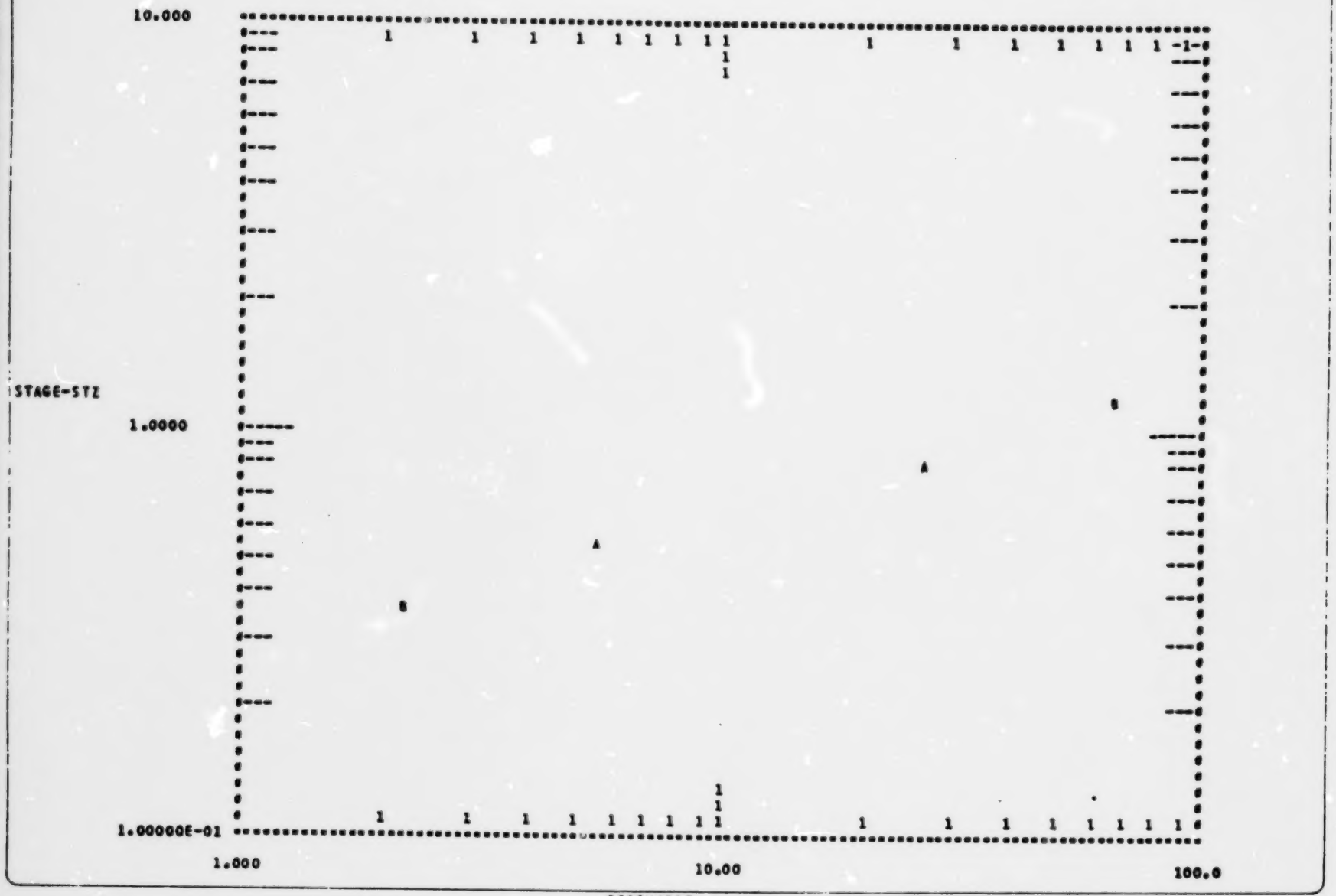

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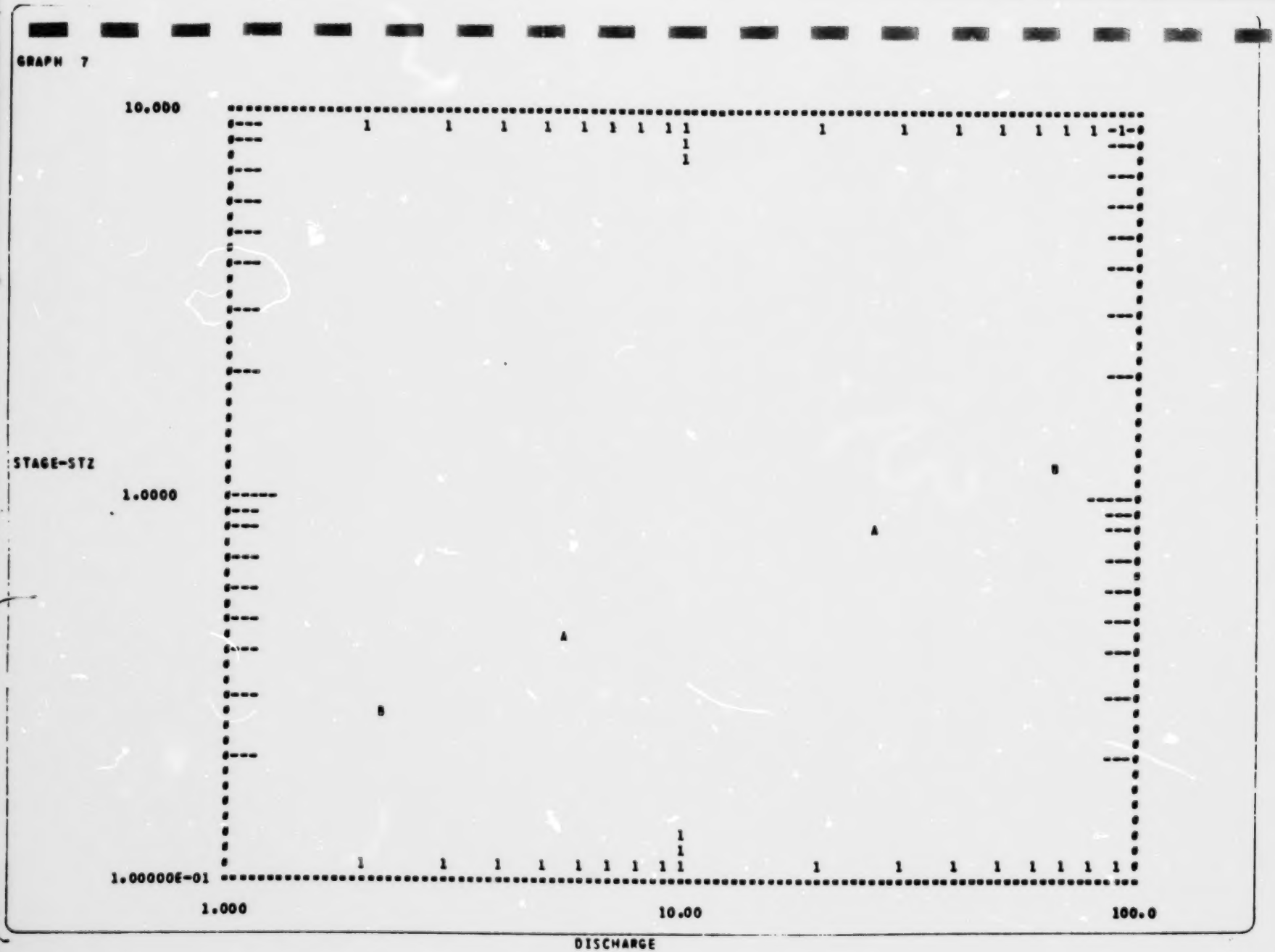

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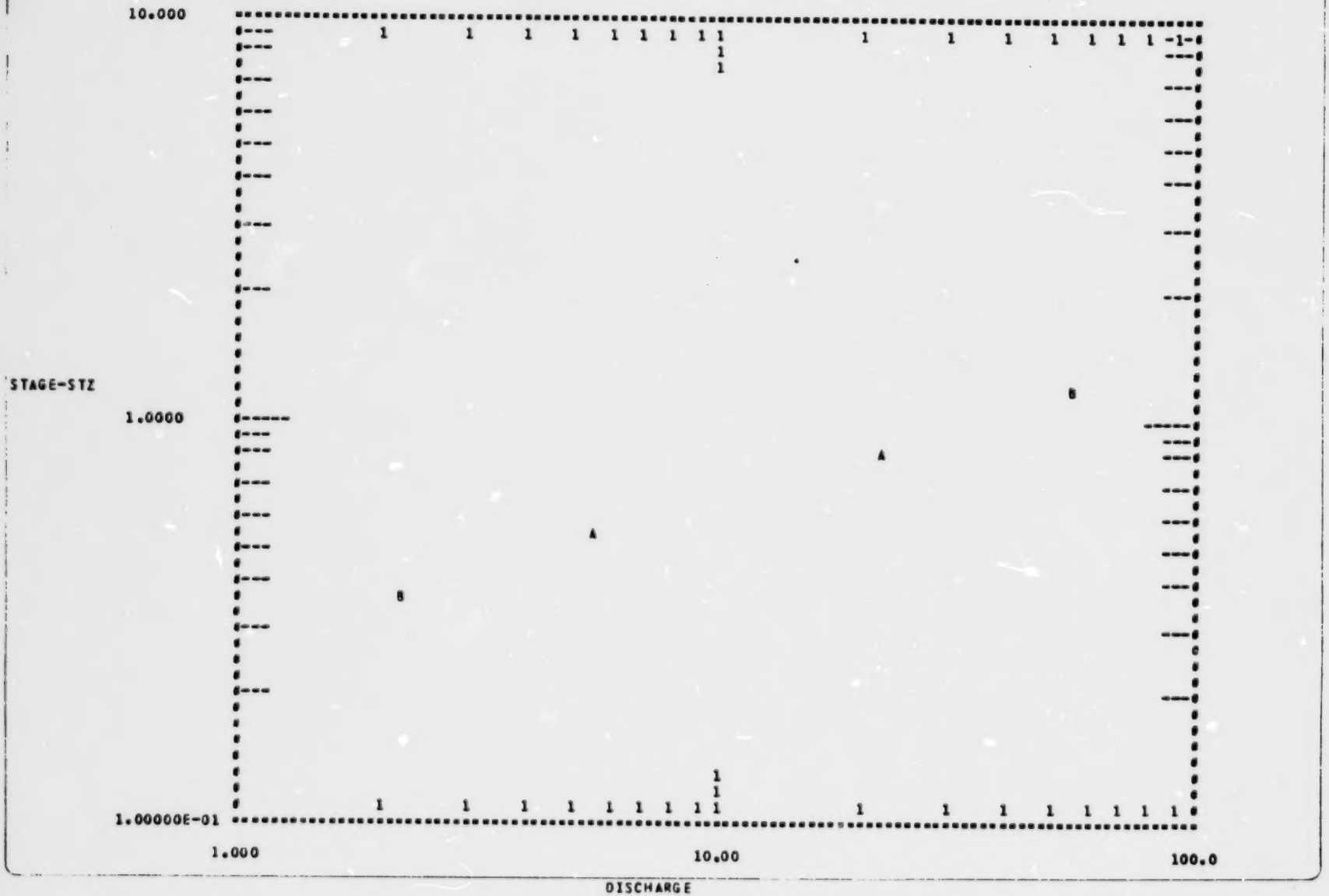

RATING CURVE FOR CROSS-SECTION 48.00

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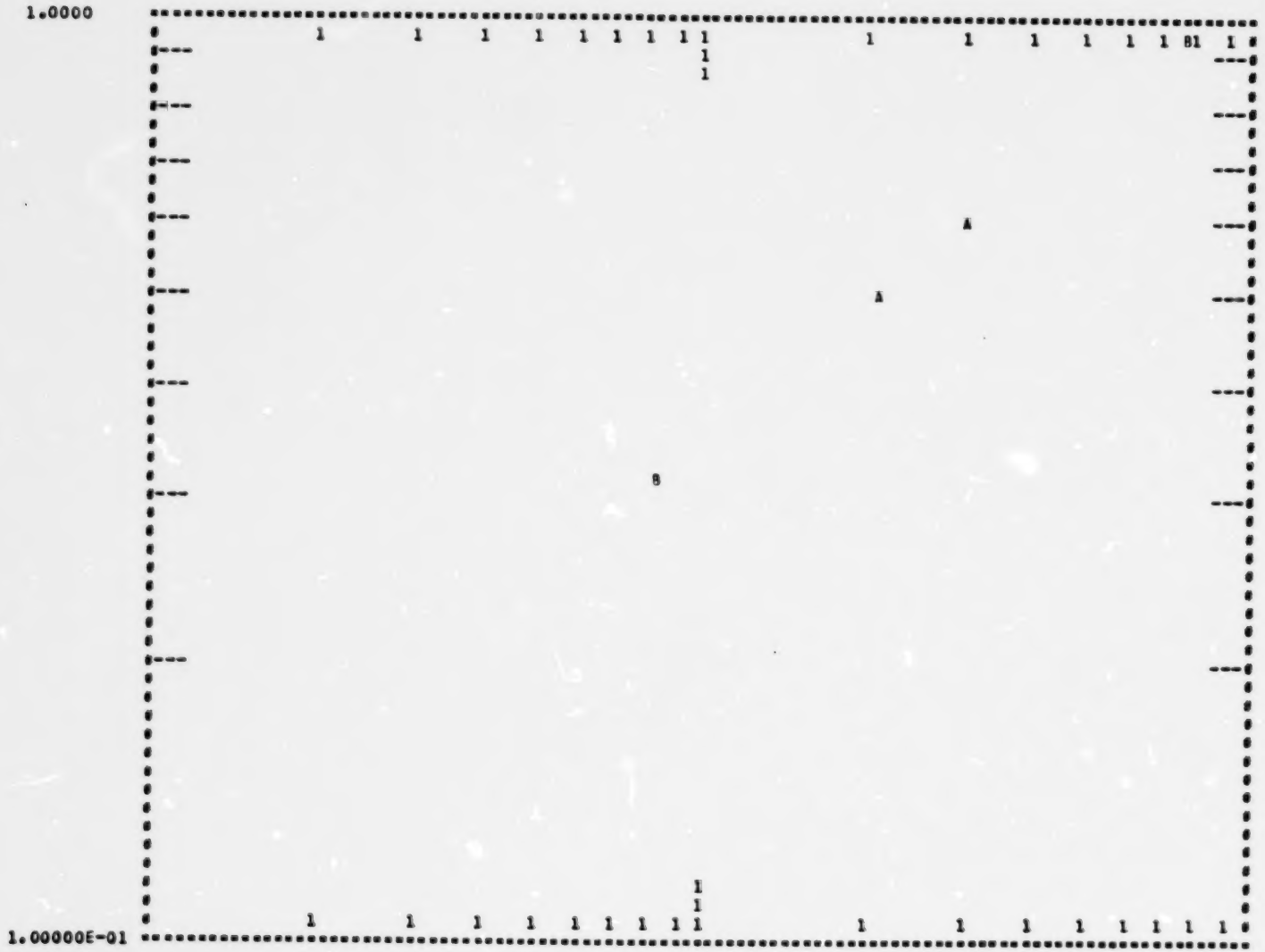

RATING CURVE FOR CROSS-SECTION 51.00

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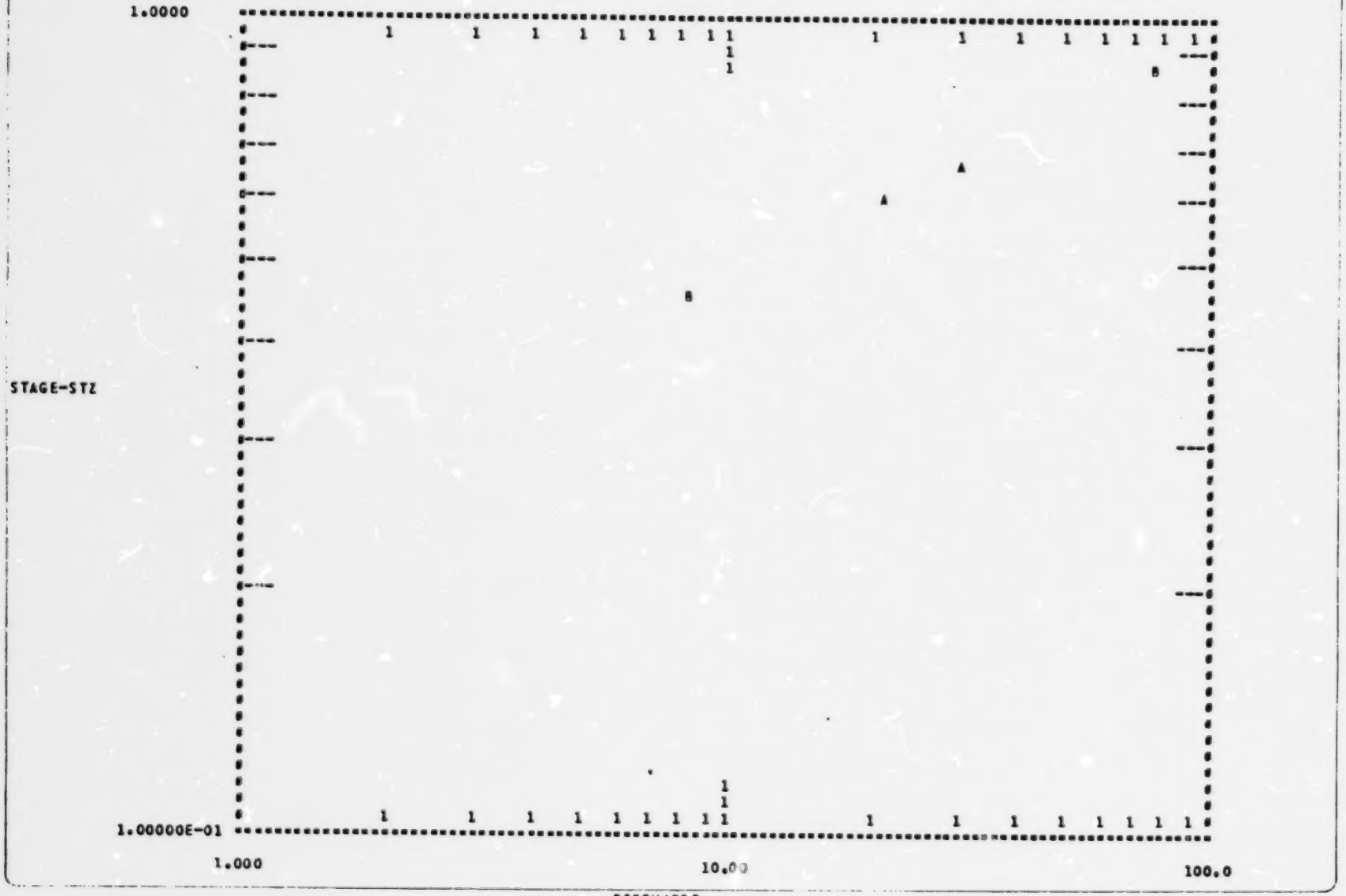

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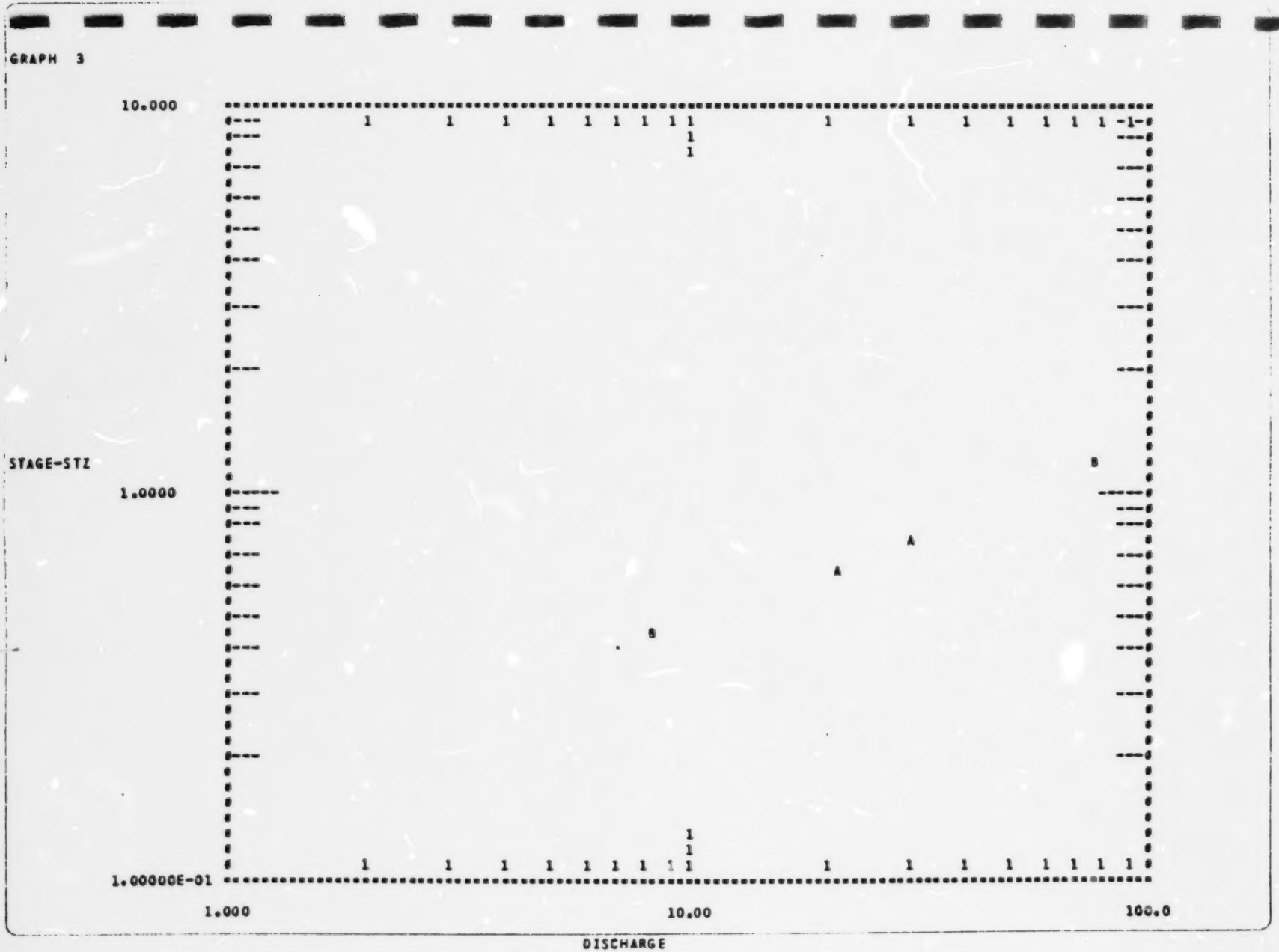

RATING CURVE FOR CROSS-SECTION 53.00

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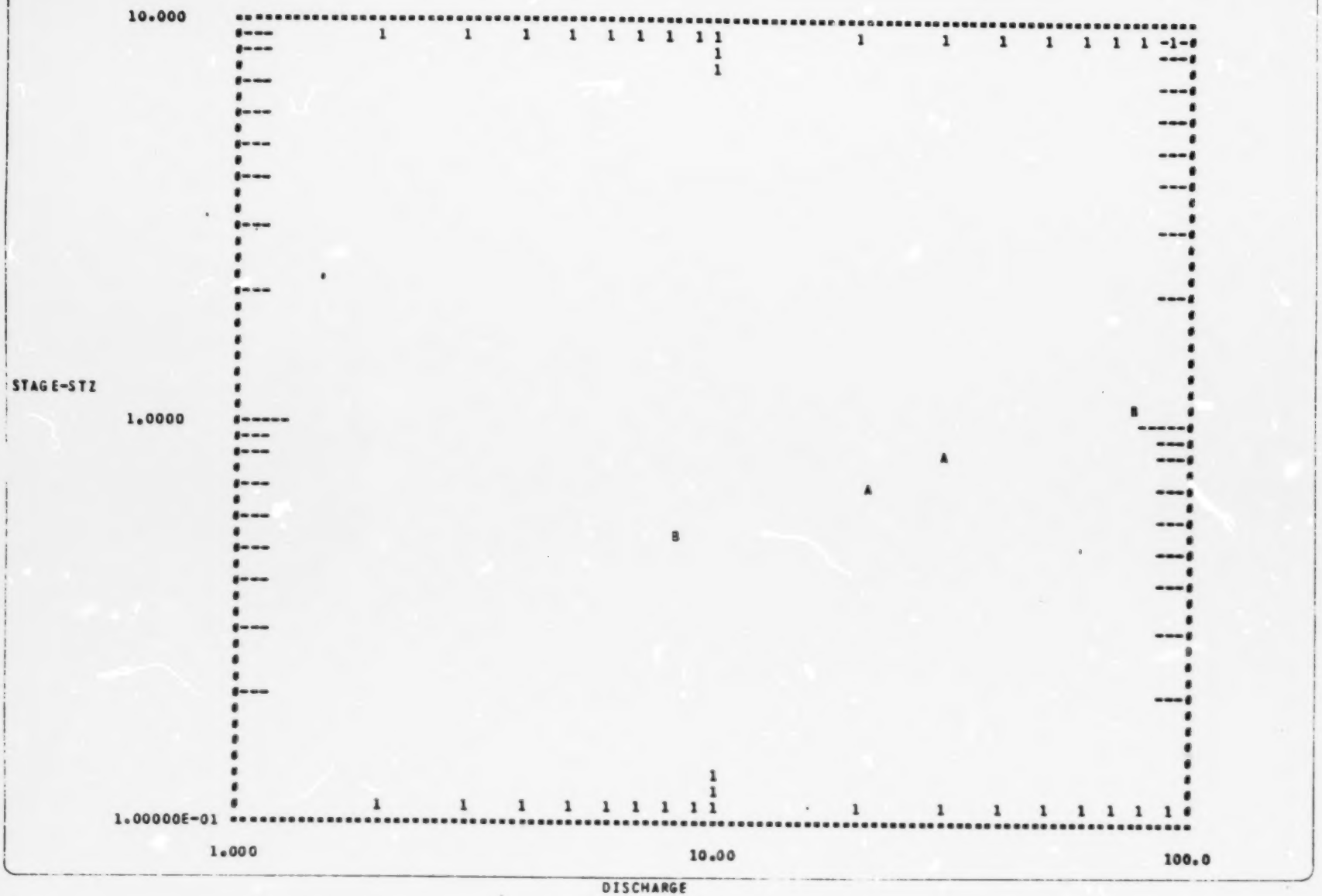

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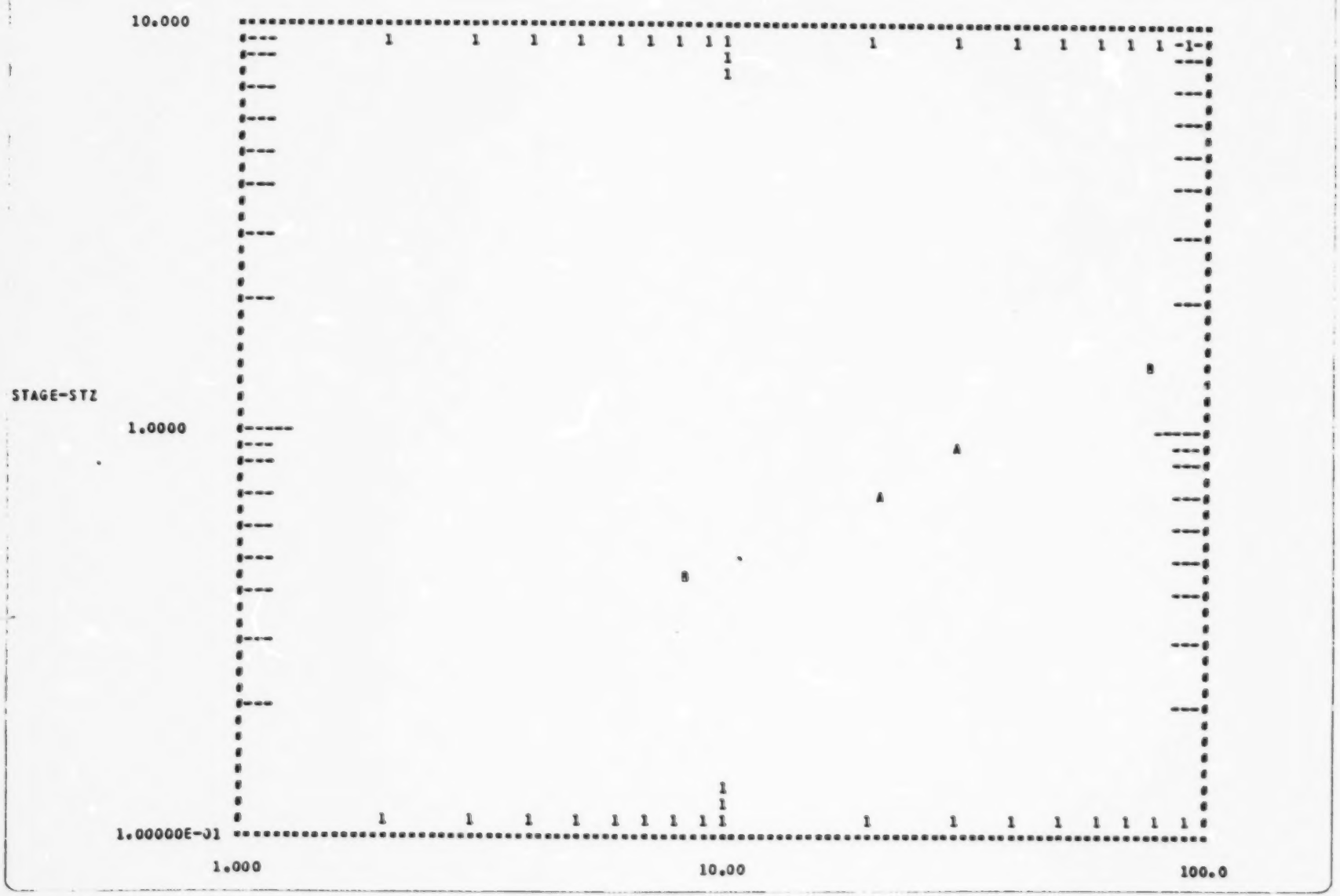

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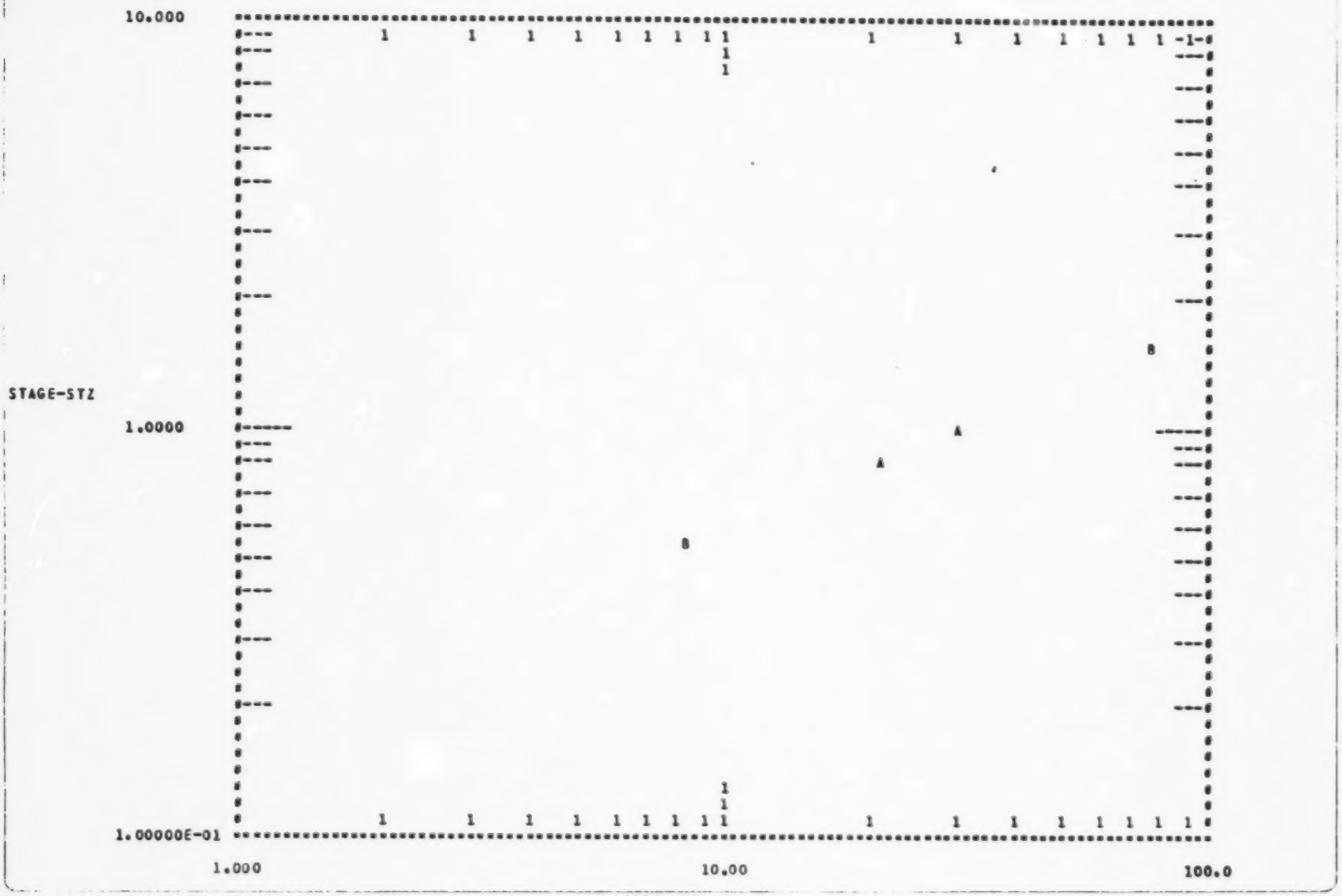

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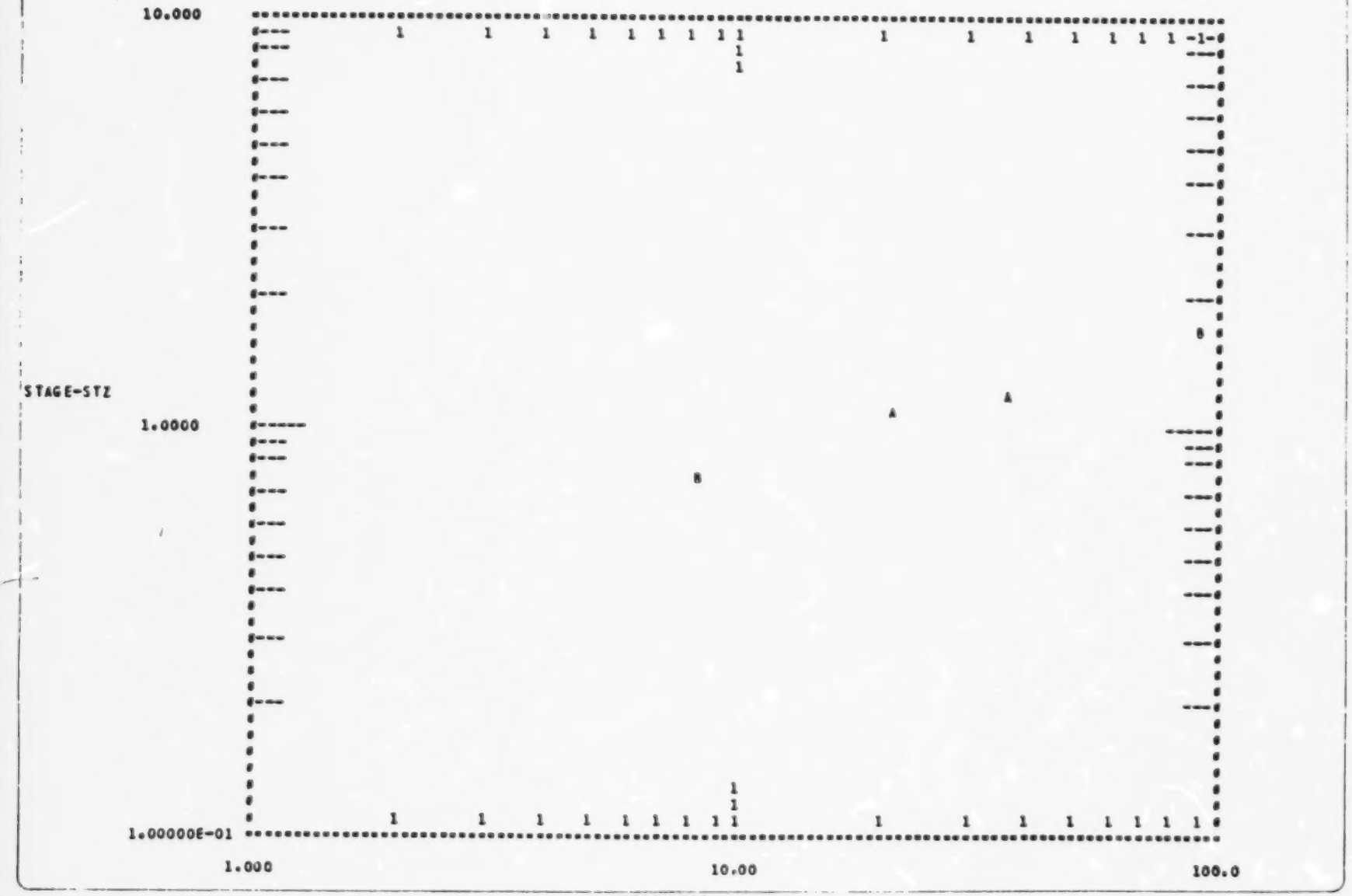
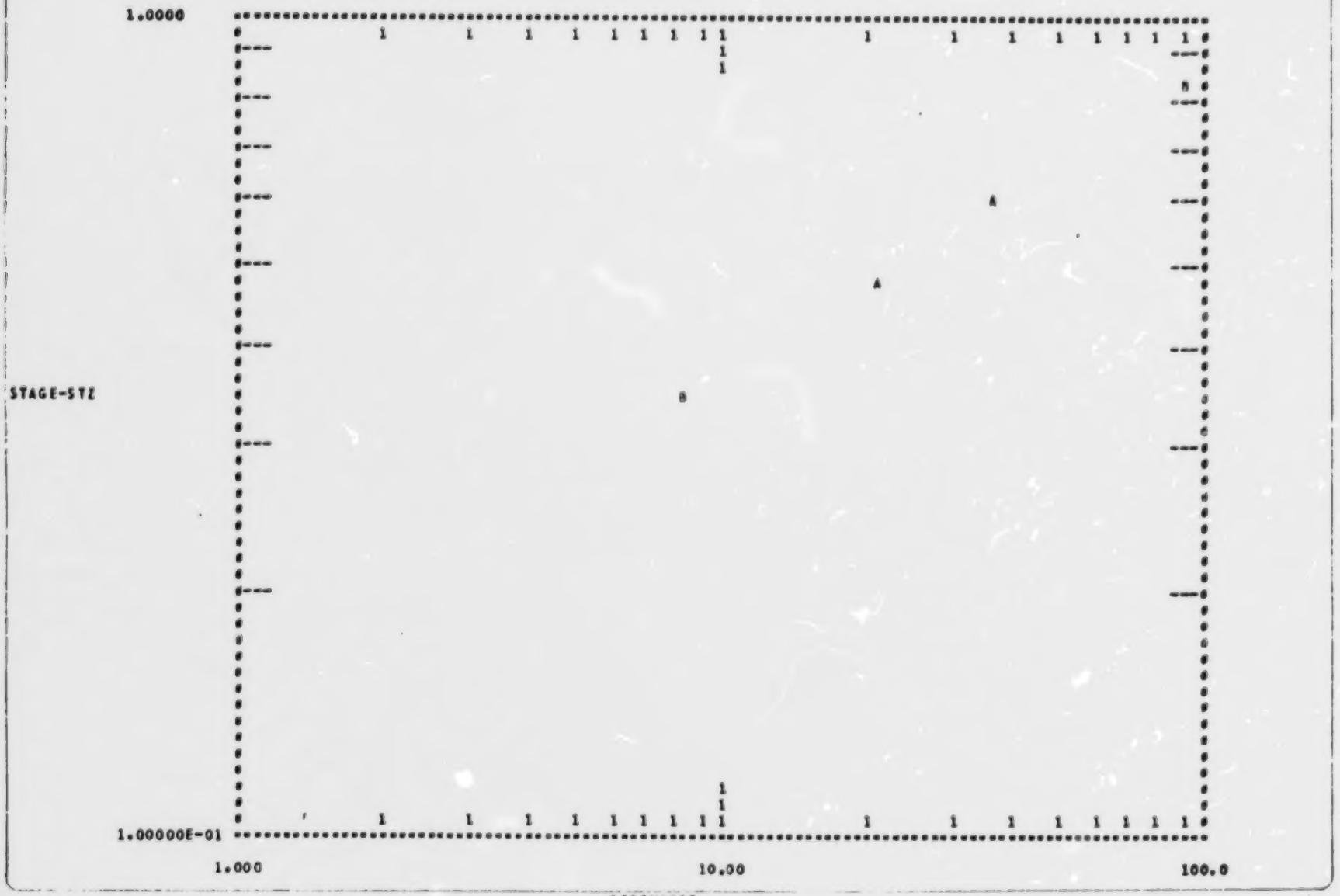


RATING CURVE FOR CROSS-SECTION 61.00

GRAPH 2



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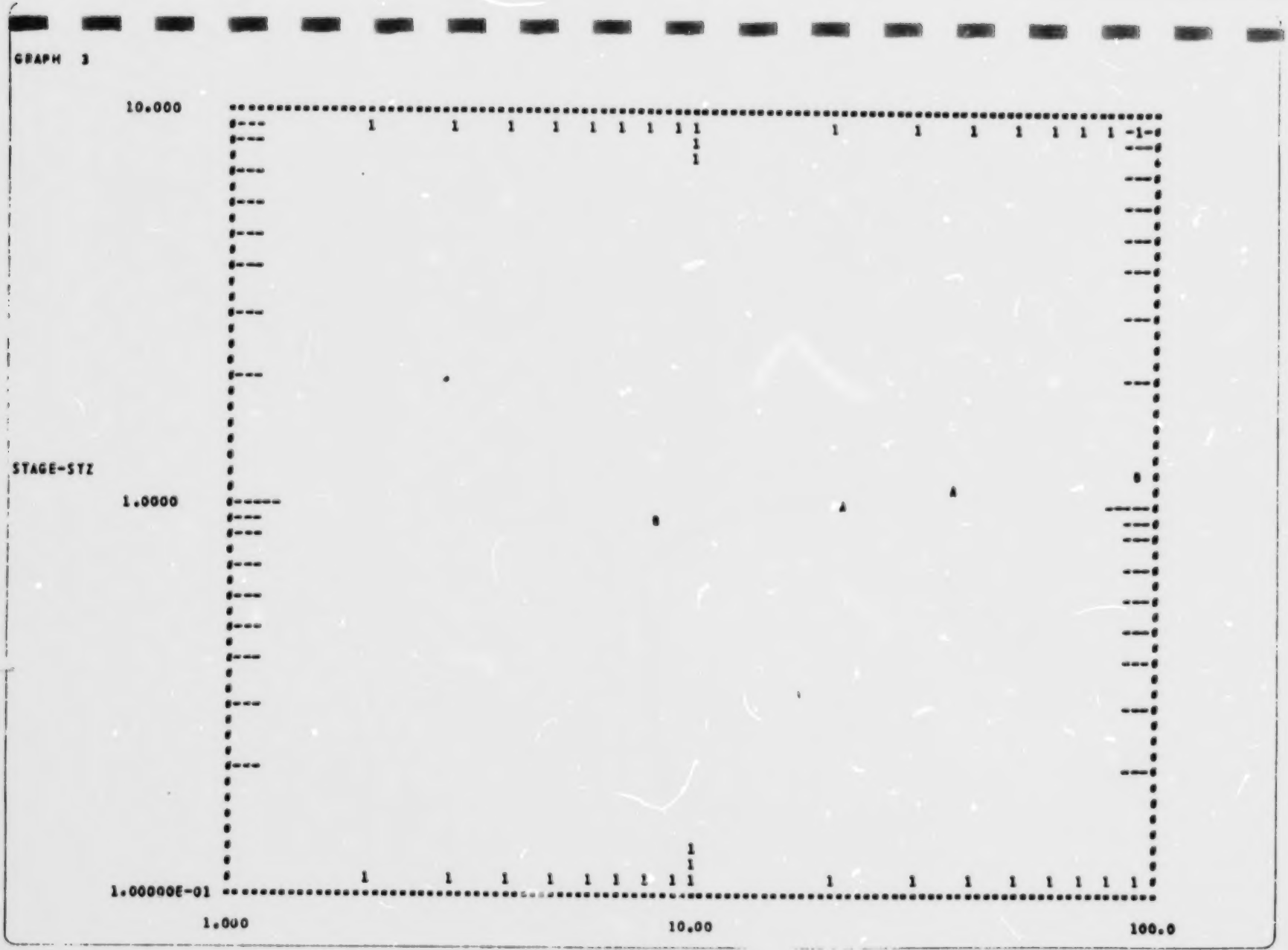

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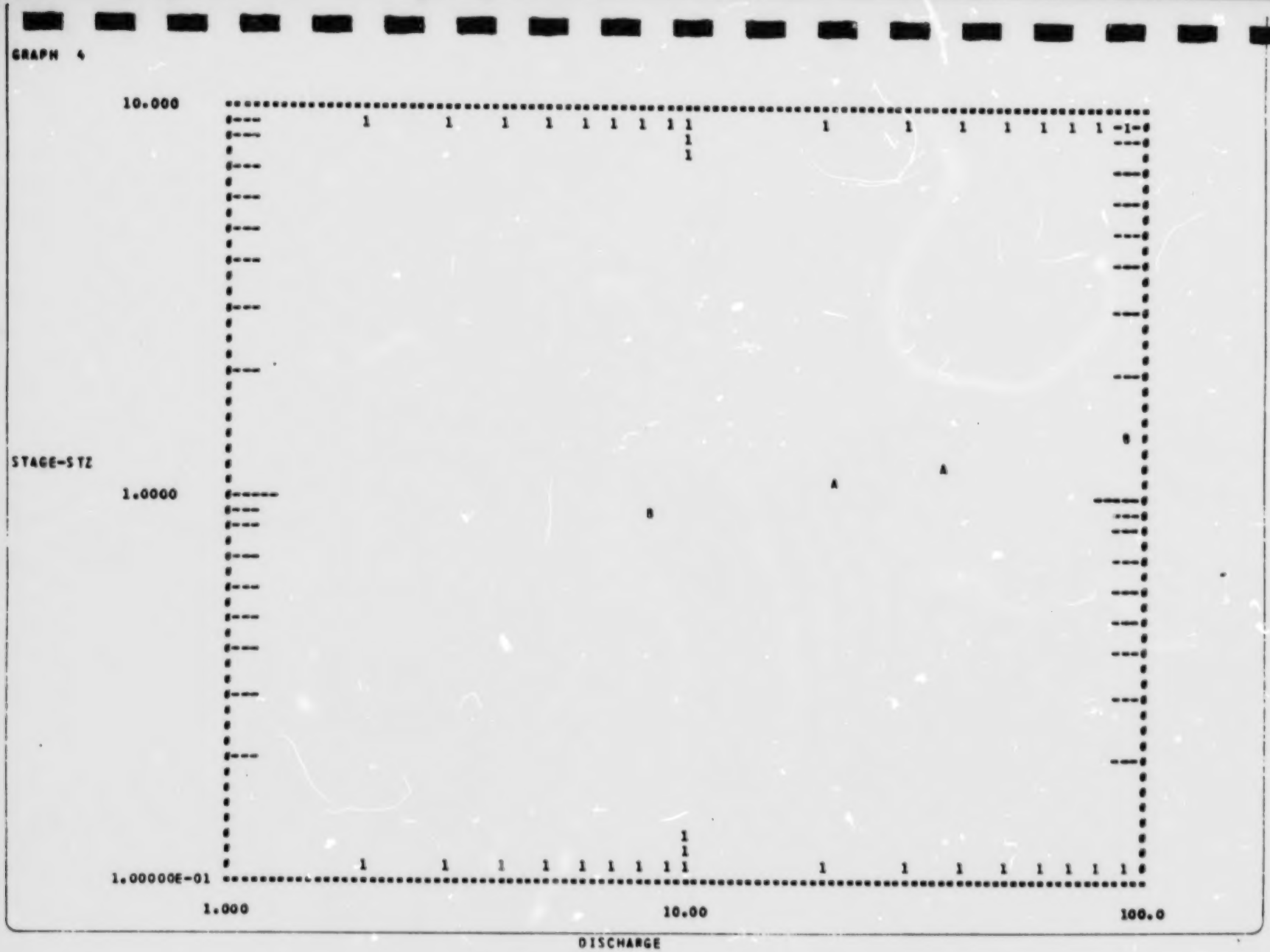

RATING CURVE FOR CROSS-SECTION 64.00

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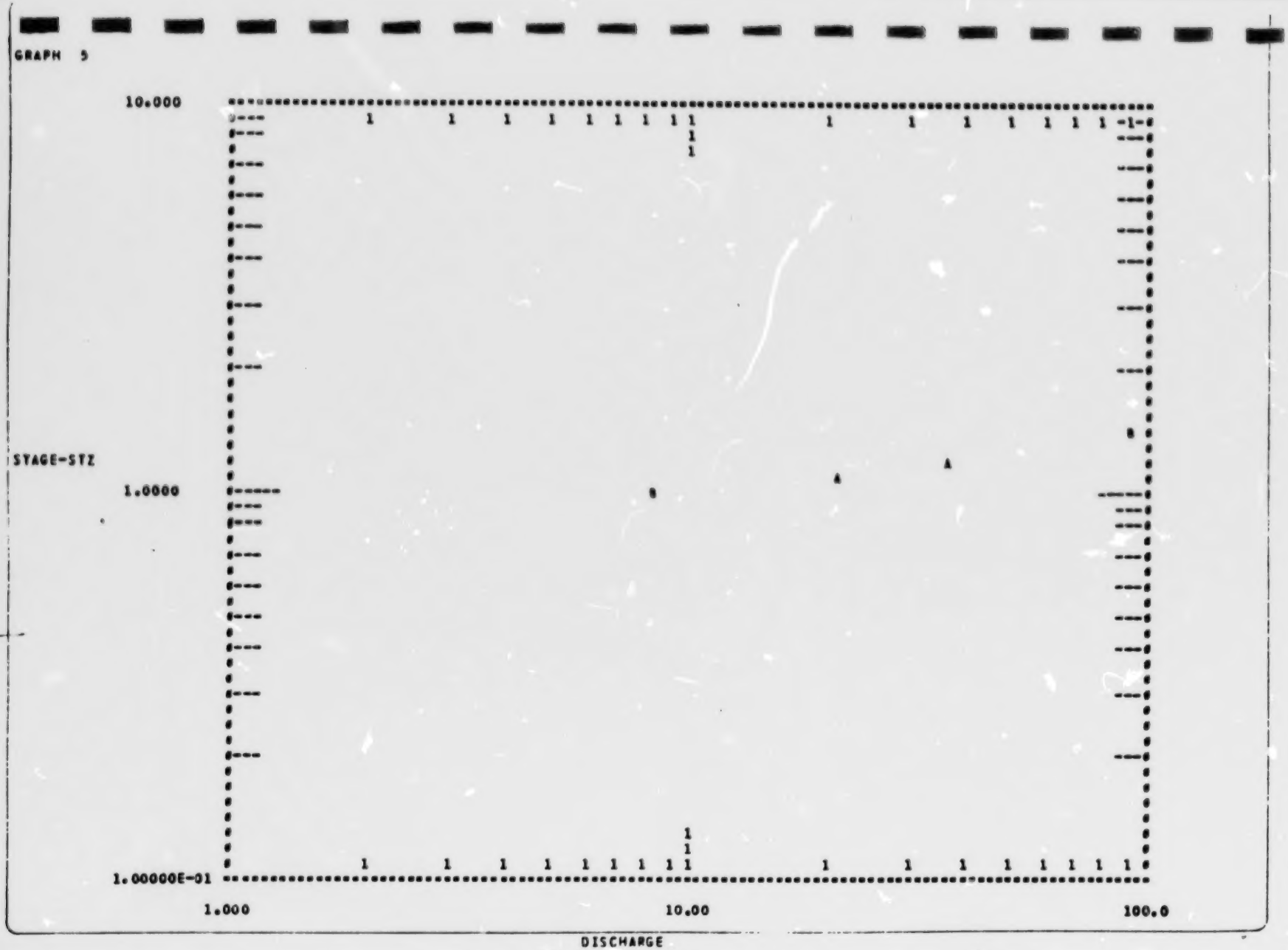

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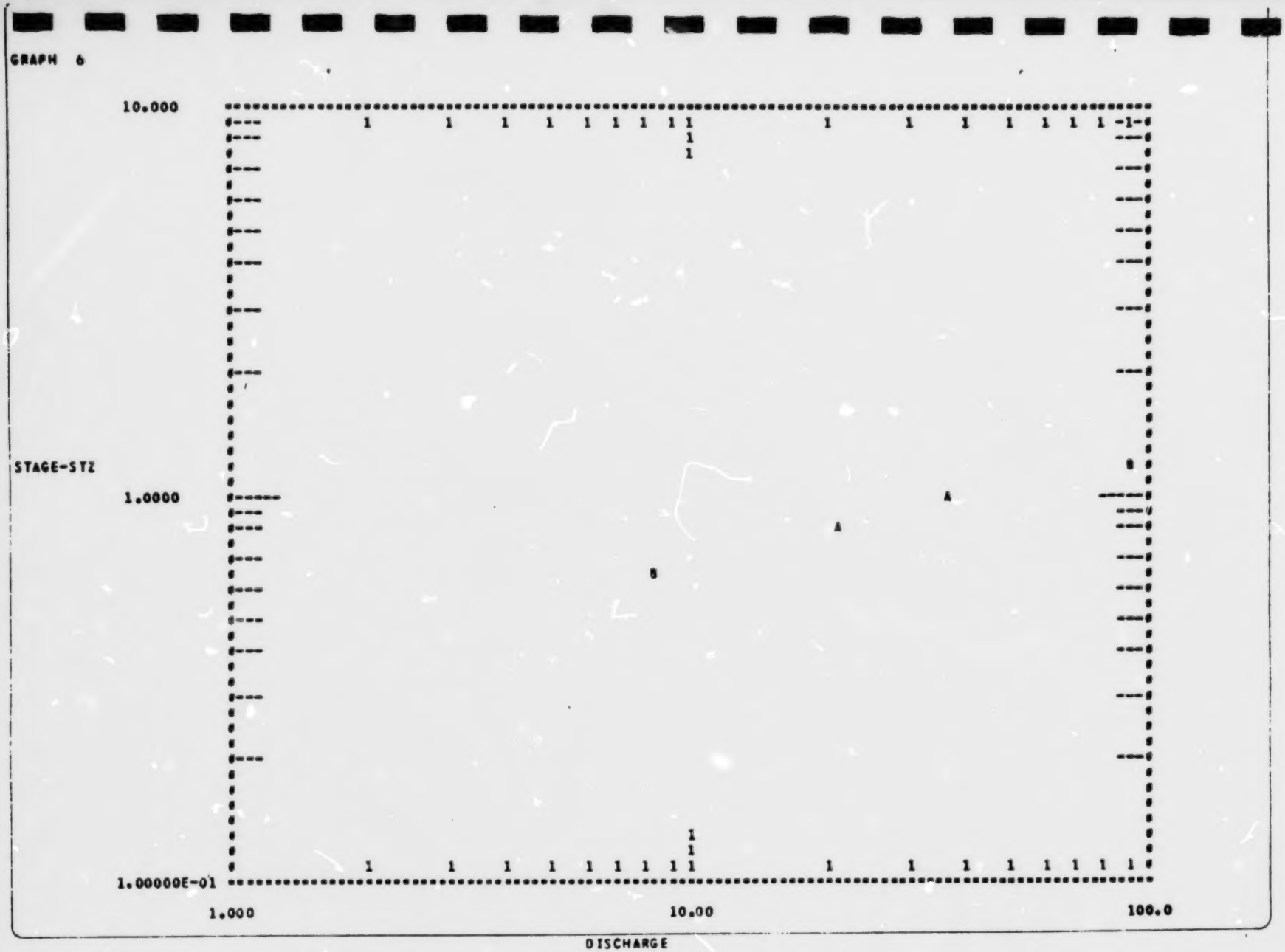
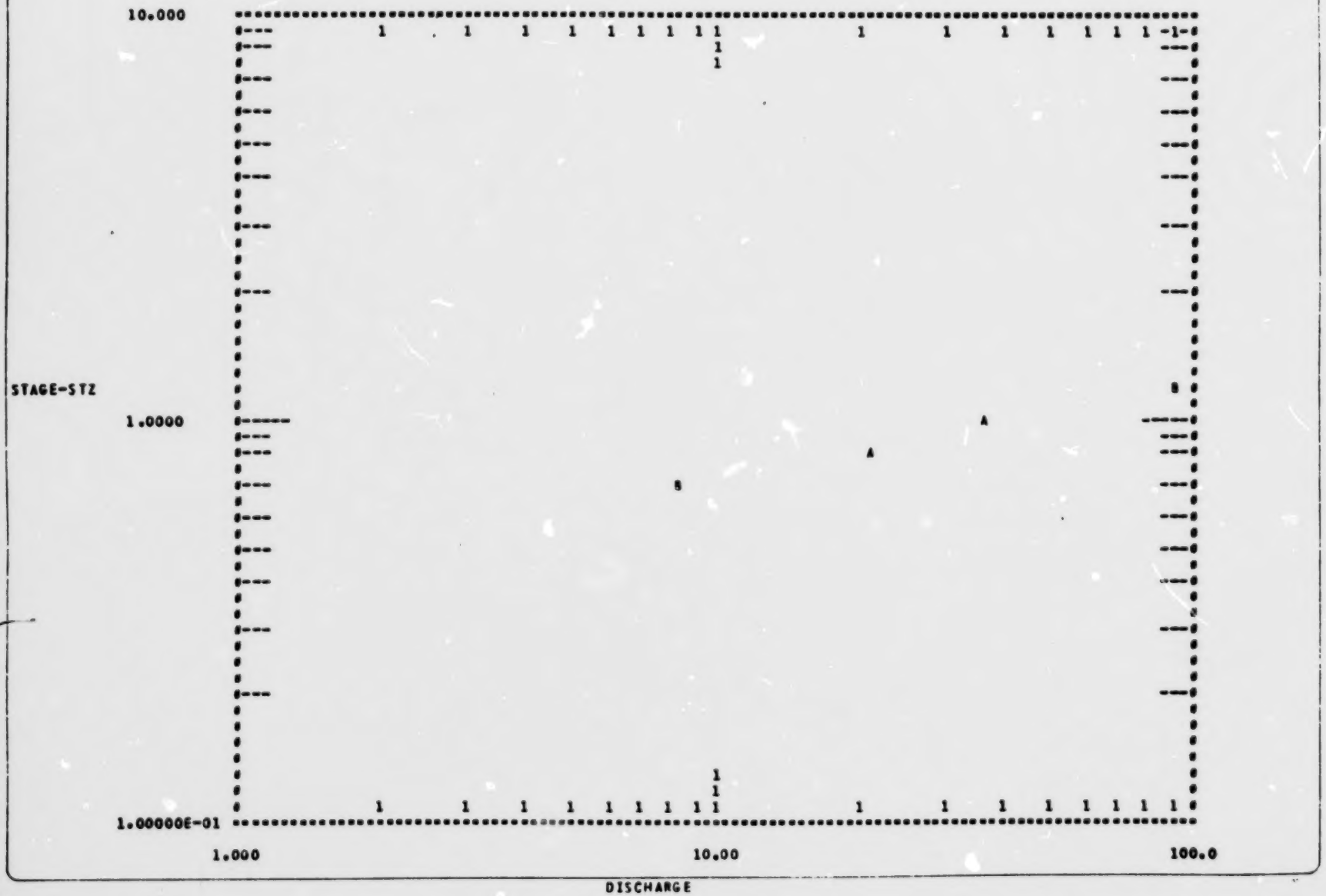
GRAPH 6



RATING CURVE FOR CROSS-SECTION 66.00

GRAPH 7

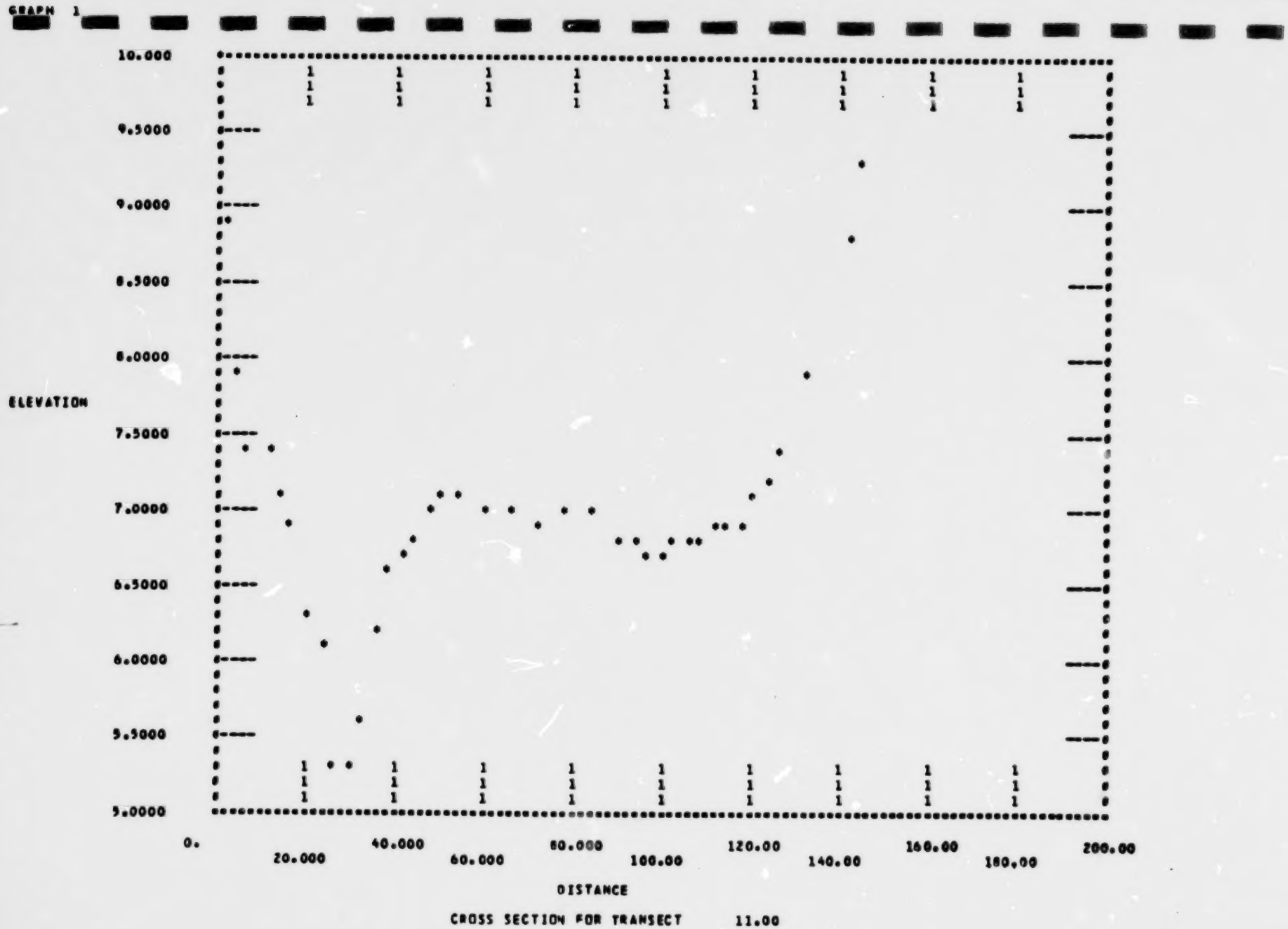


RATING CURVE FOR CROSS-SECTION 67.00

PART II

CROSS-SECTIONAL PROFILES AT STUDY TRANSECTS

The profiles of each study transect, from the left-hand downstream headpin to right-hand headpin are illustrated in Part II of this data appendix. Each cross-section is identified by two ordinal numbers; for example, cross-section 11.00 represents the profile for transect 1 at study reach 1. Transect 1 is always the downstream transect in each study area.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9.0000
8.5000
8.0000
ELEVATION
7.5000
7.0000
6.5000
6.0000
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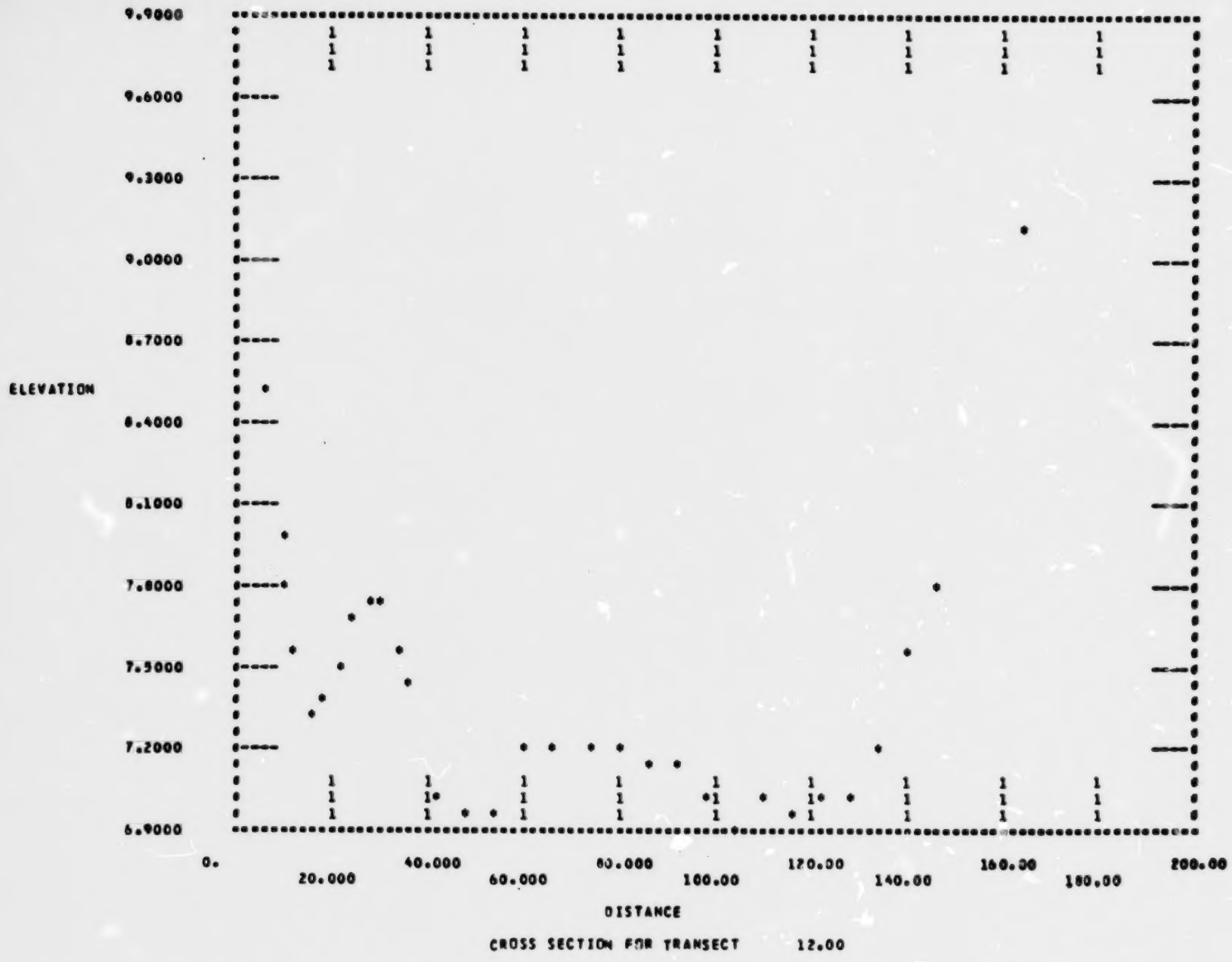
5.0000
0.
20.000
40.000
60.000
80.000
100.00
120.00
140.00
160.00
180.00
200.00
DISTANCE
CROSS SECTION FOR TRANSECT 11.00



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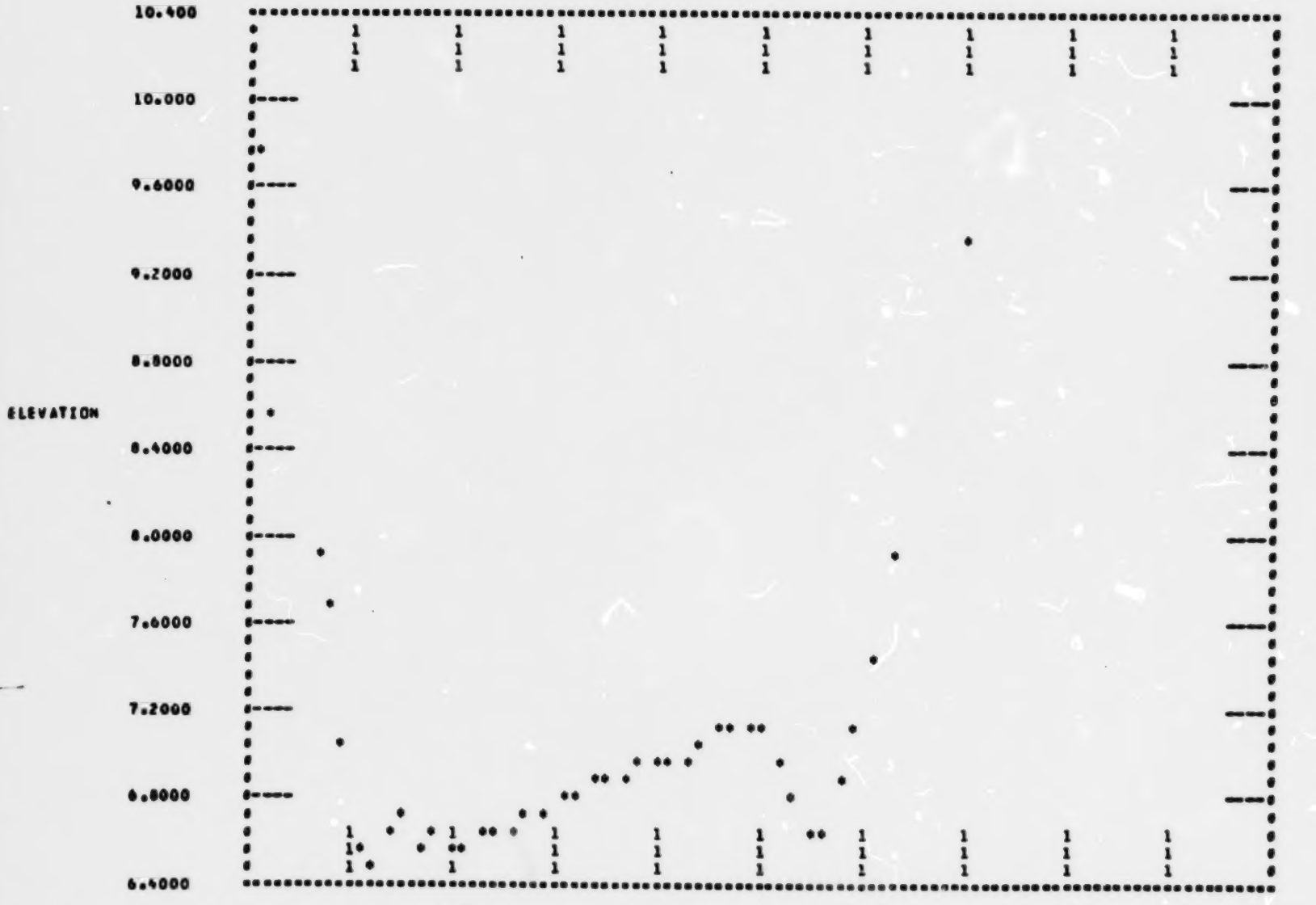

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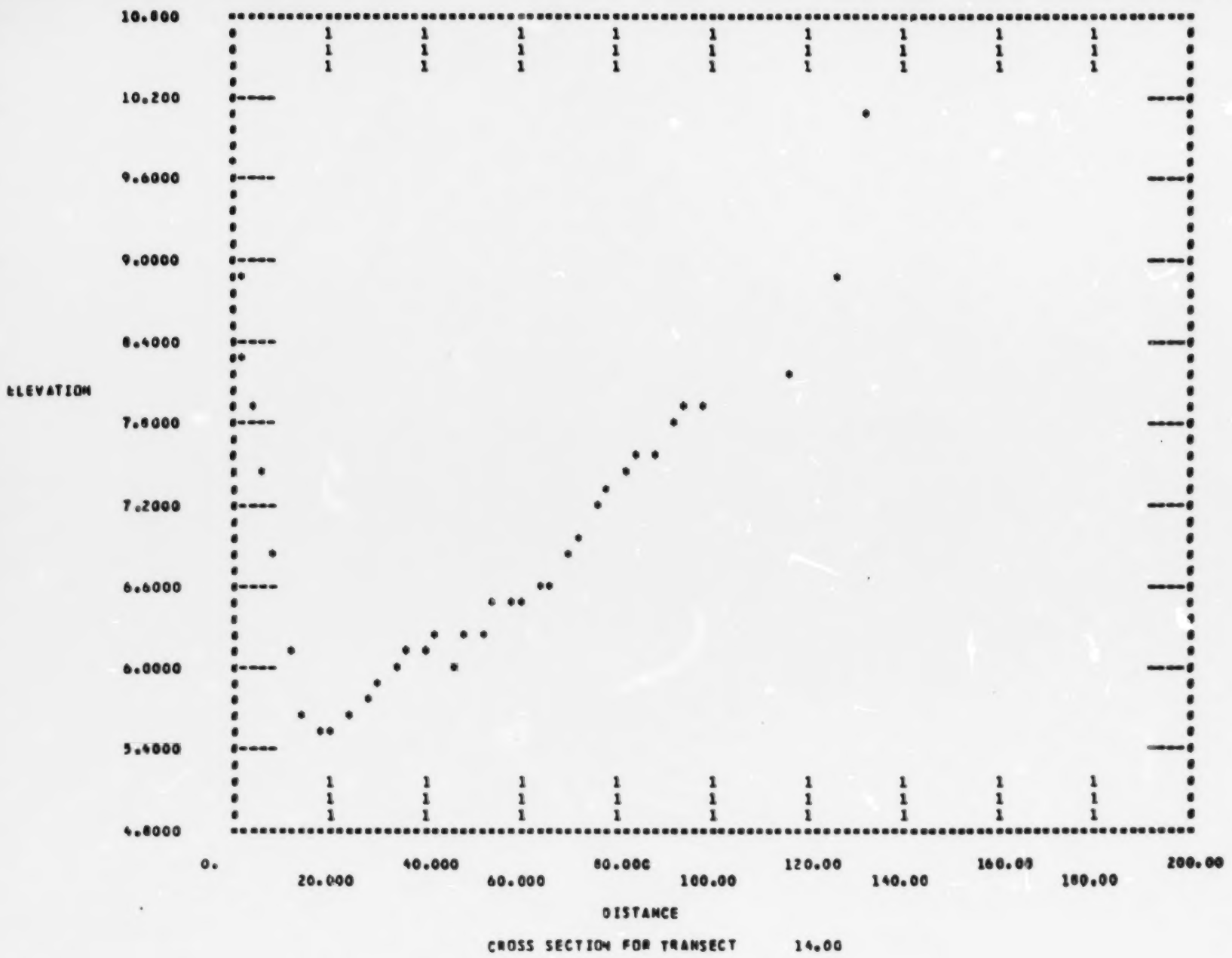

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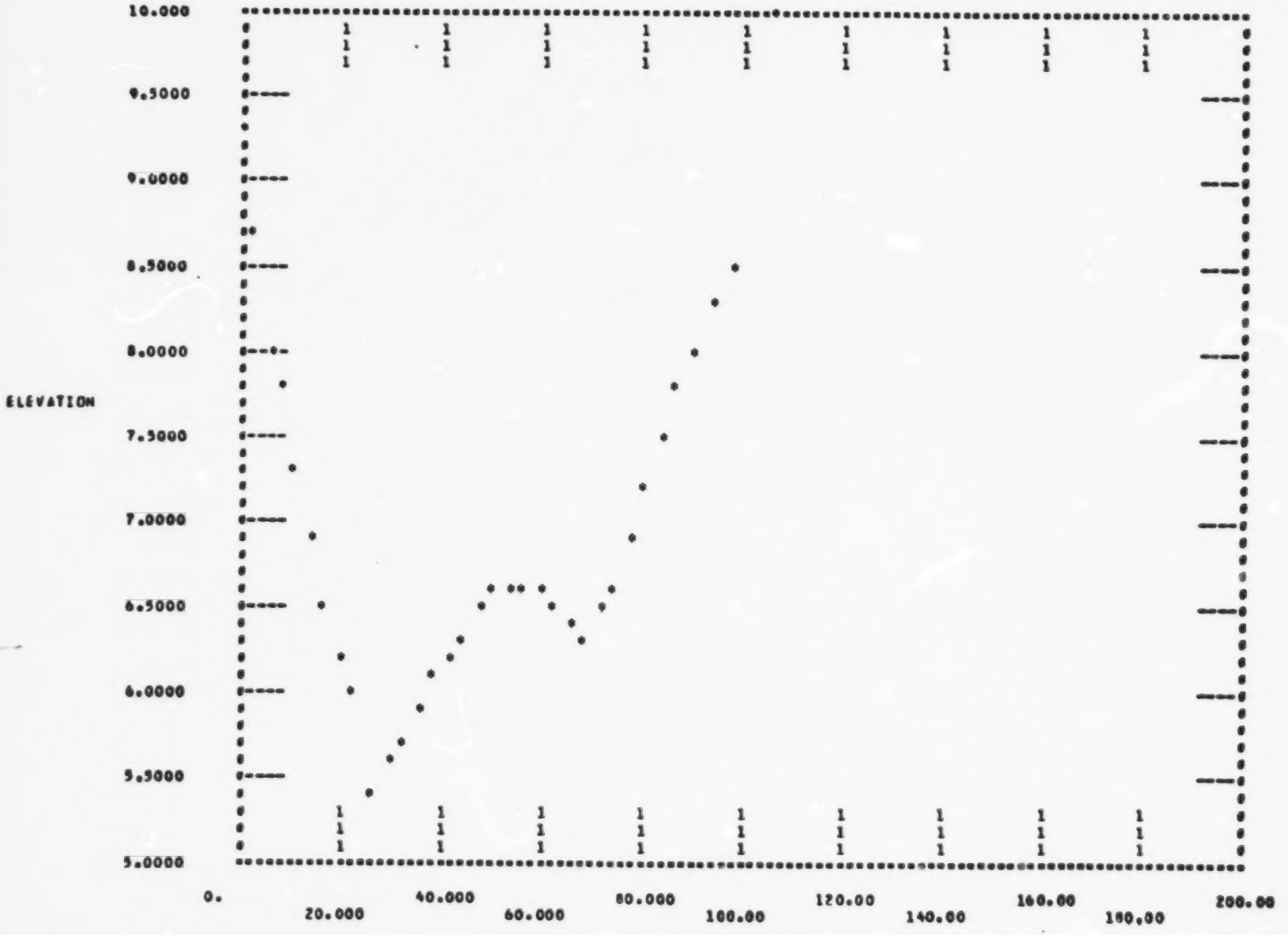
GRAPH 41



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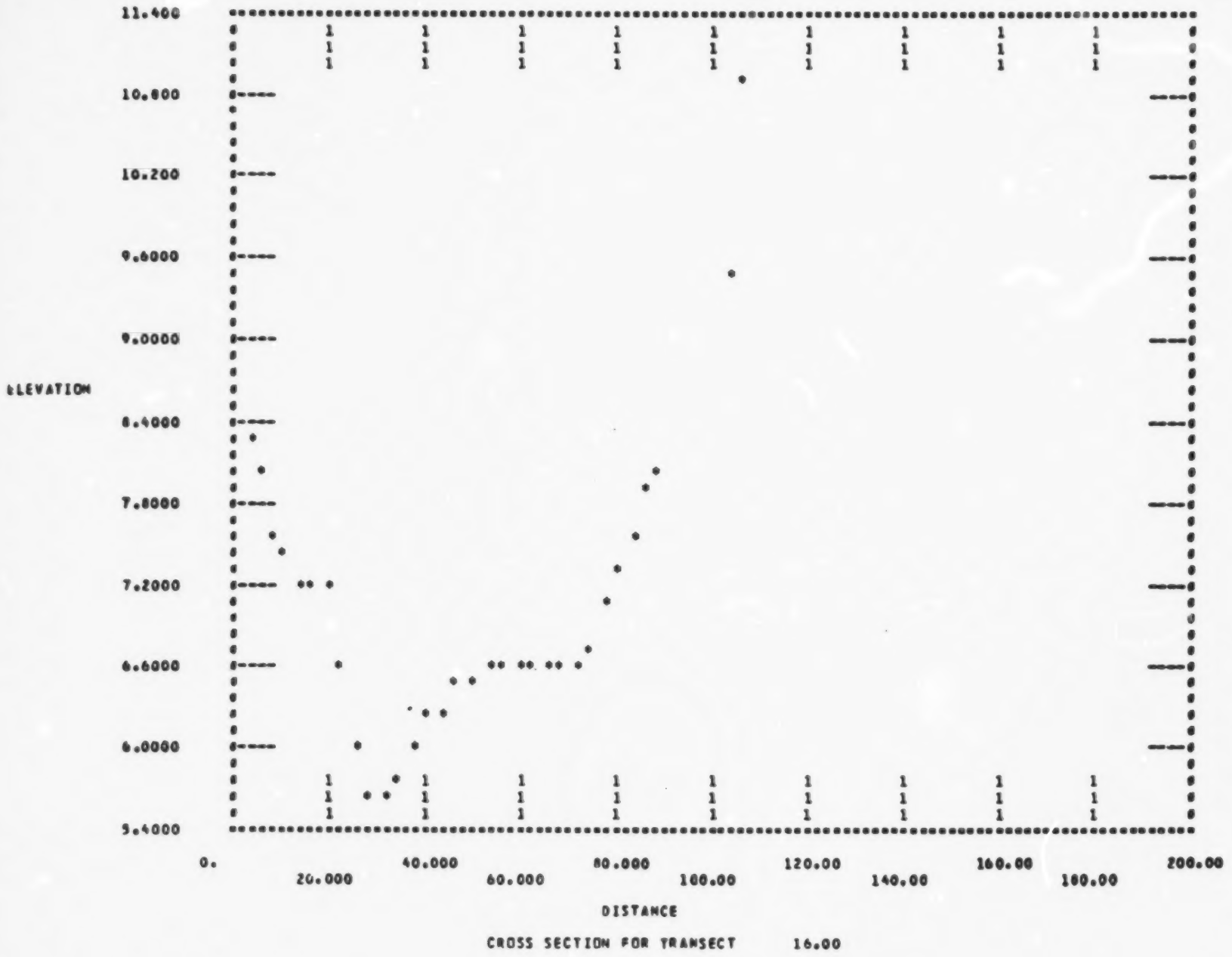

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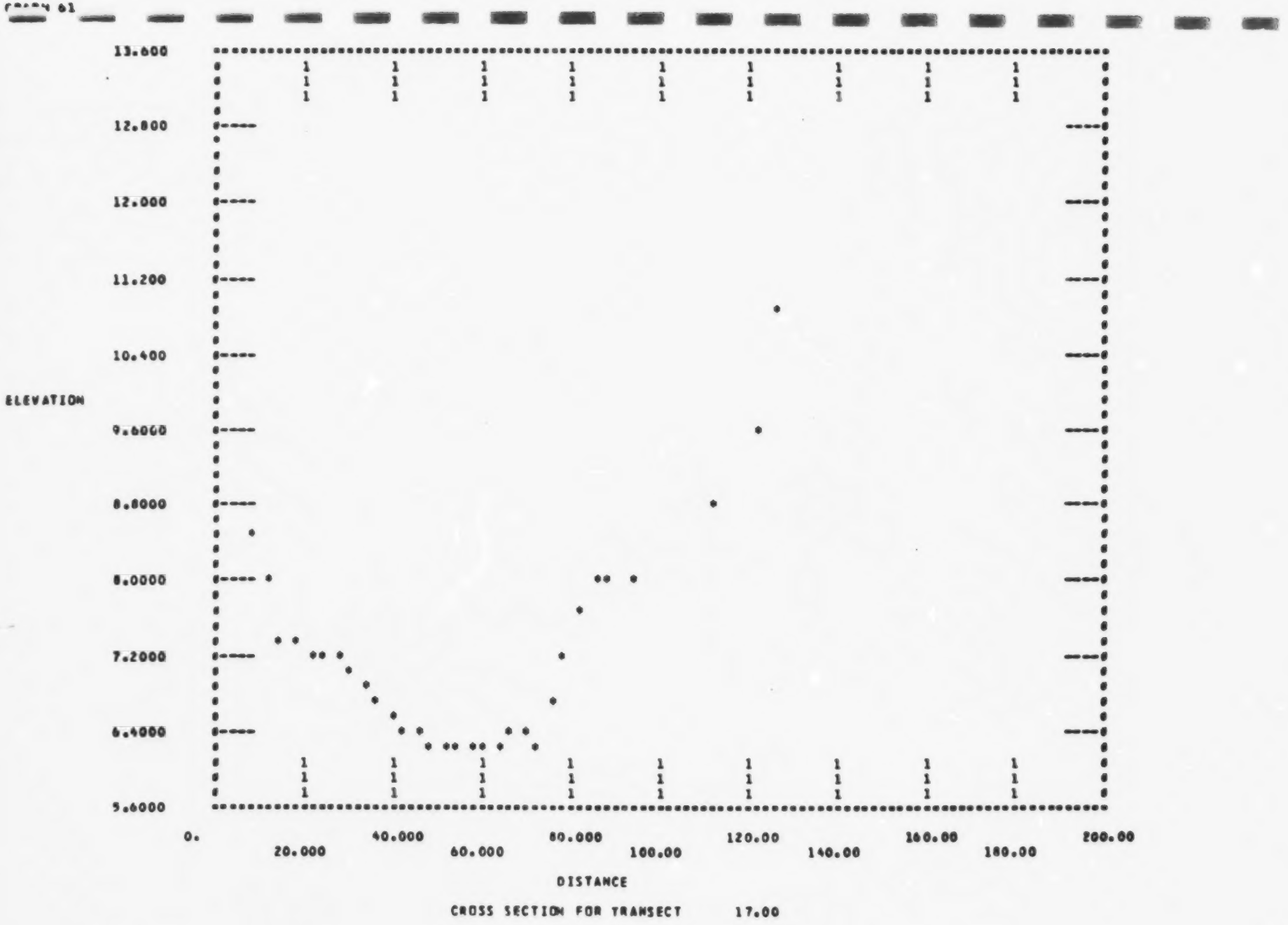

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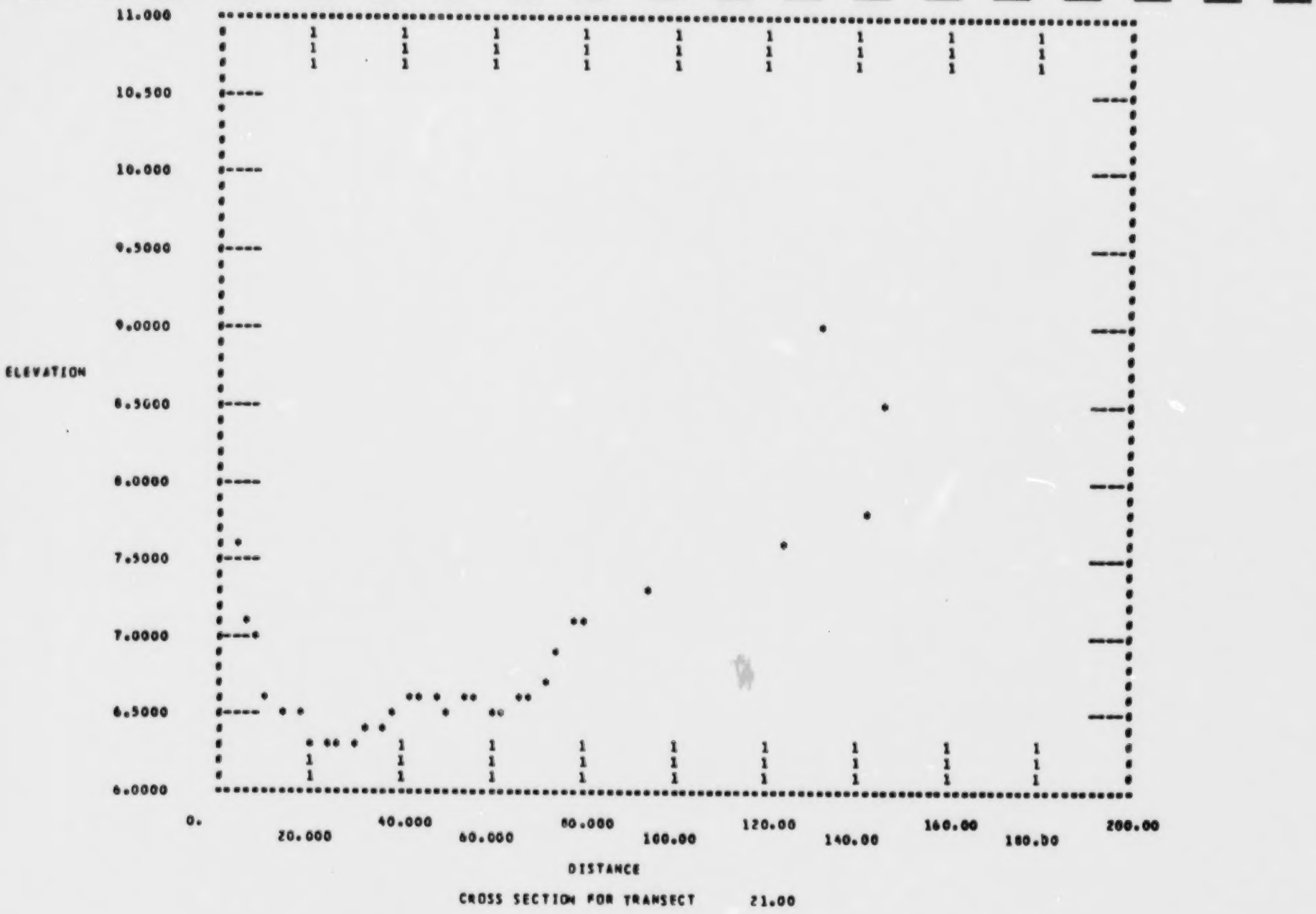

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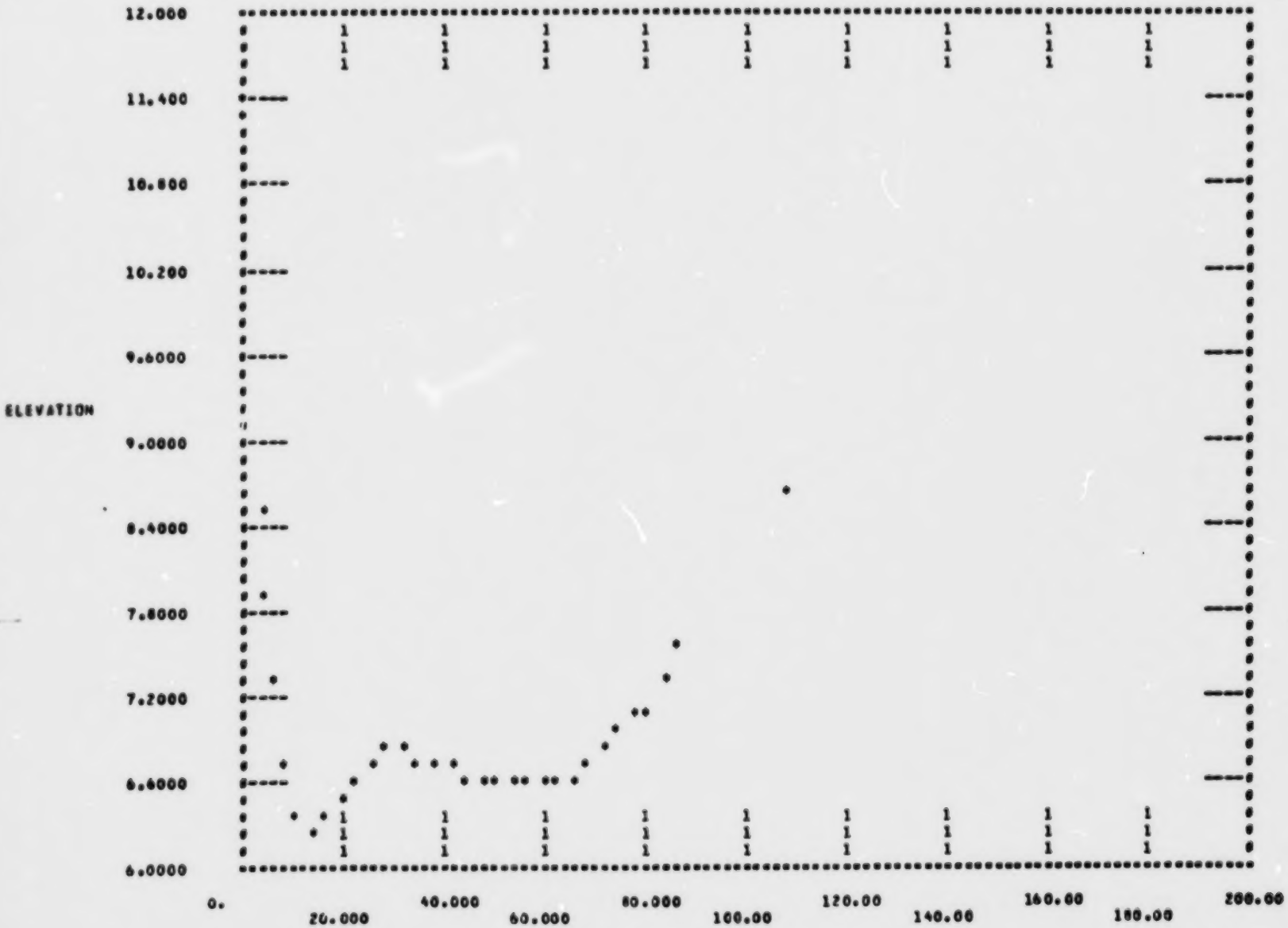

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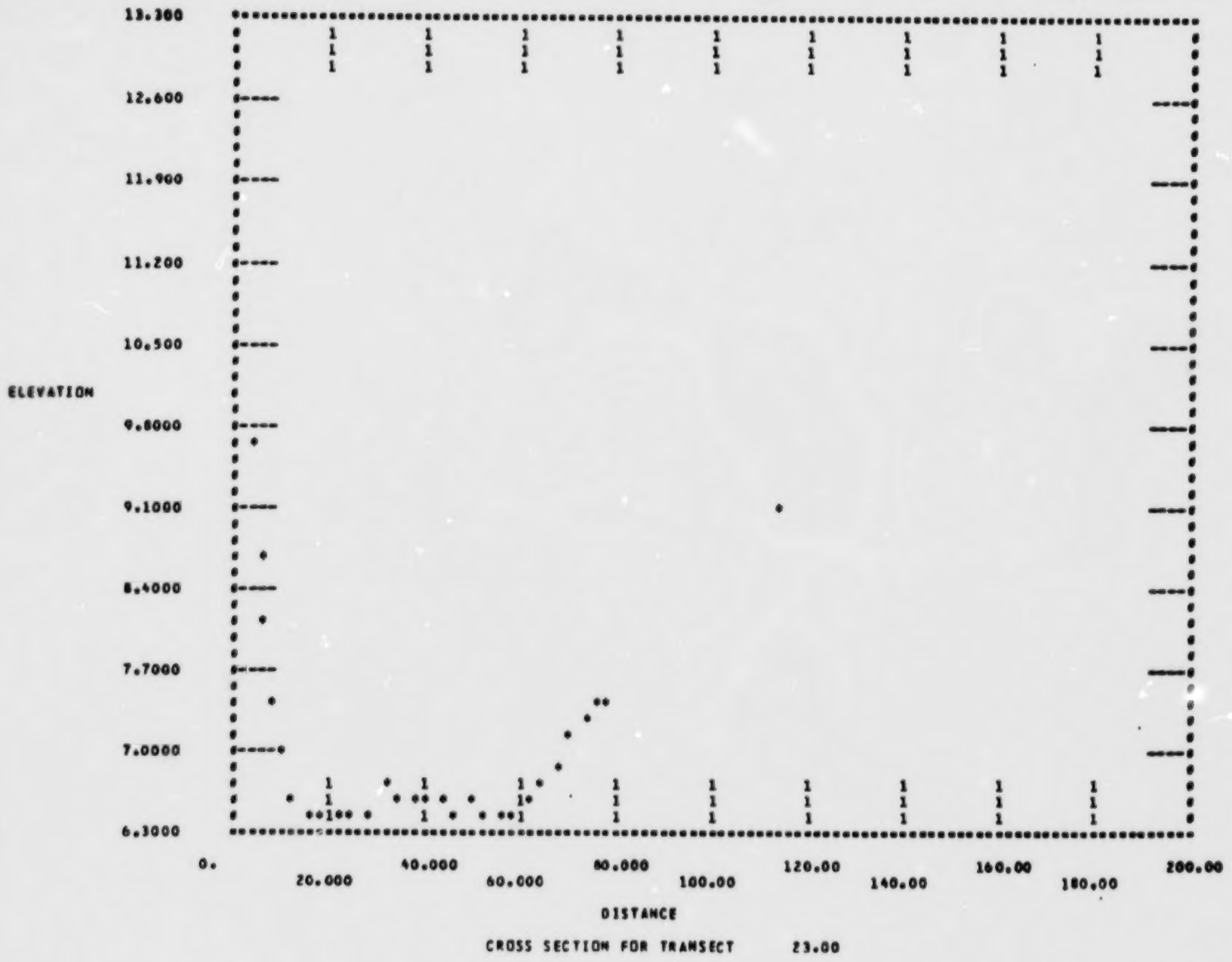

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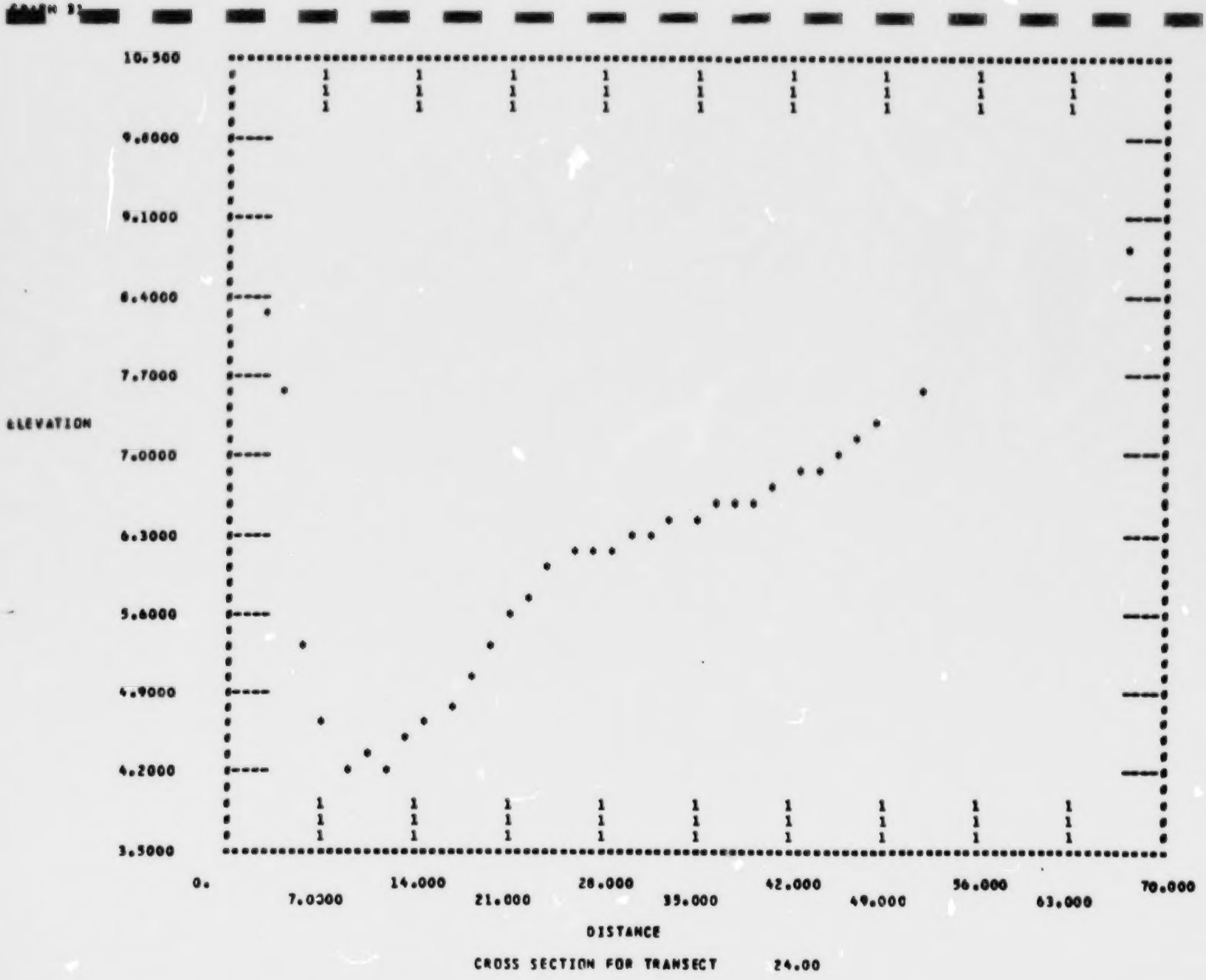

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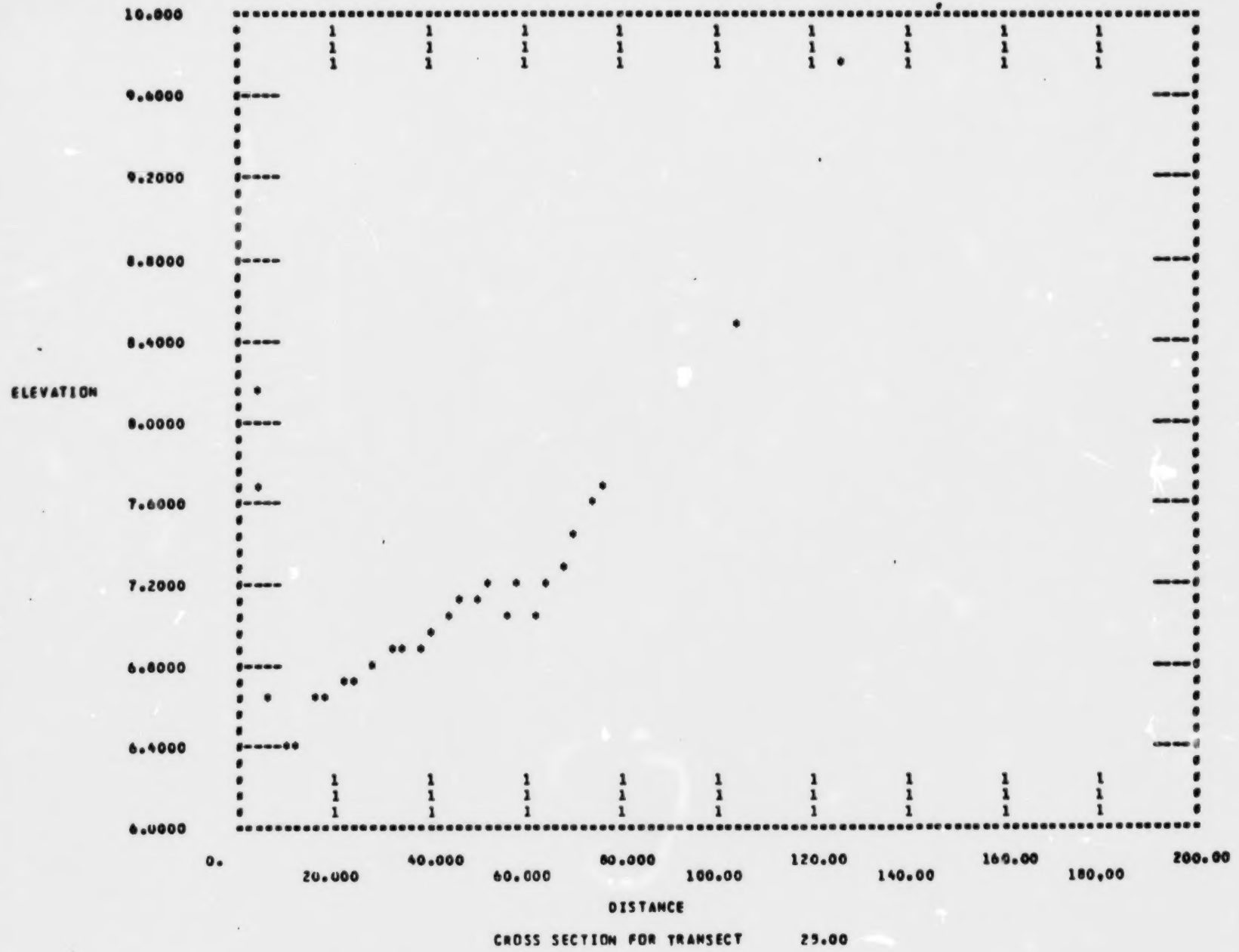
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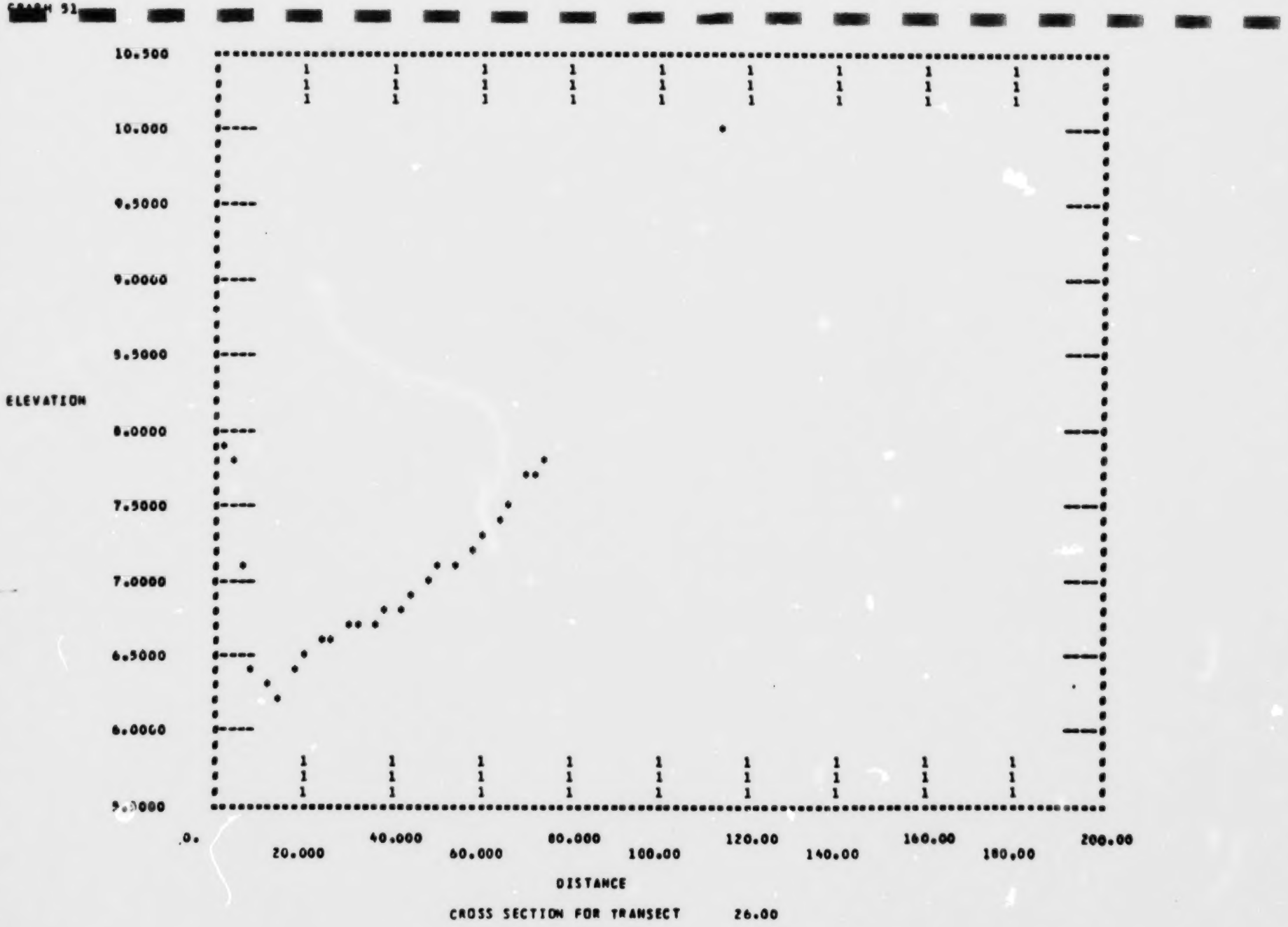
7.2000
6.8000
6.4000
6.0000
0.
20.000
40.000
60.000
80.000
100.00
120.00
140.00
160.00
180.00
200.00
DISTANCE
CROSS SECTION FOR TRANSECT 25.00



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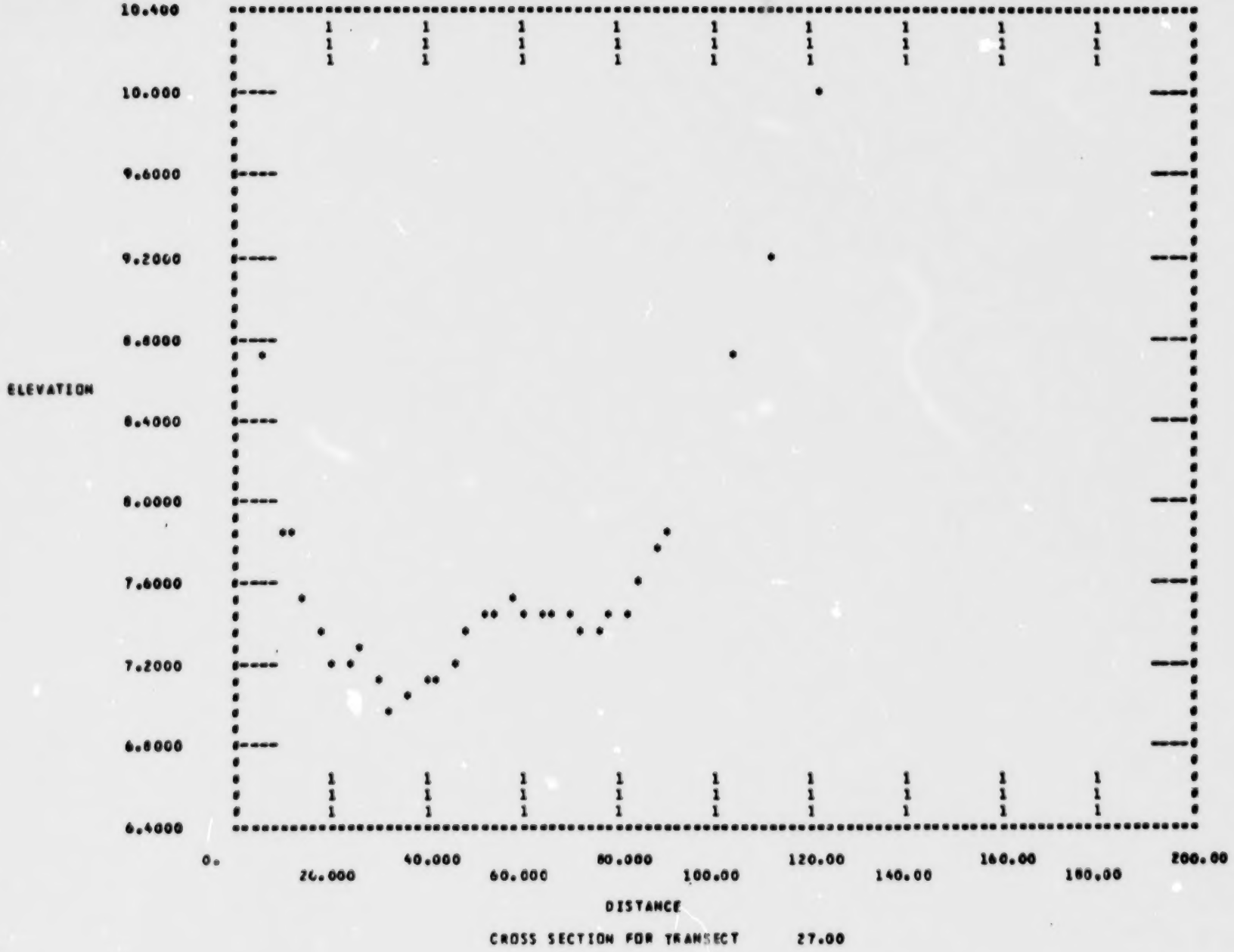

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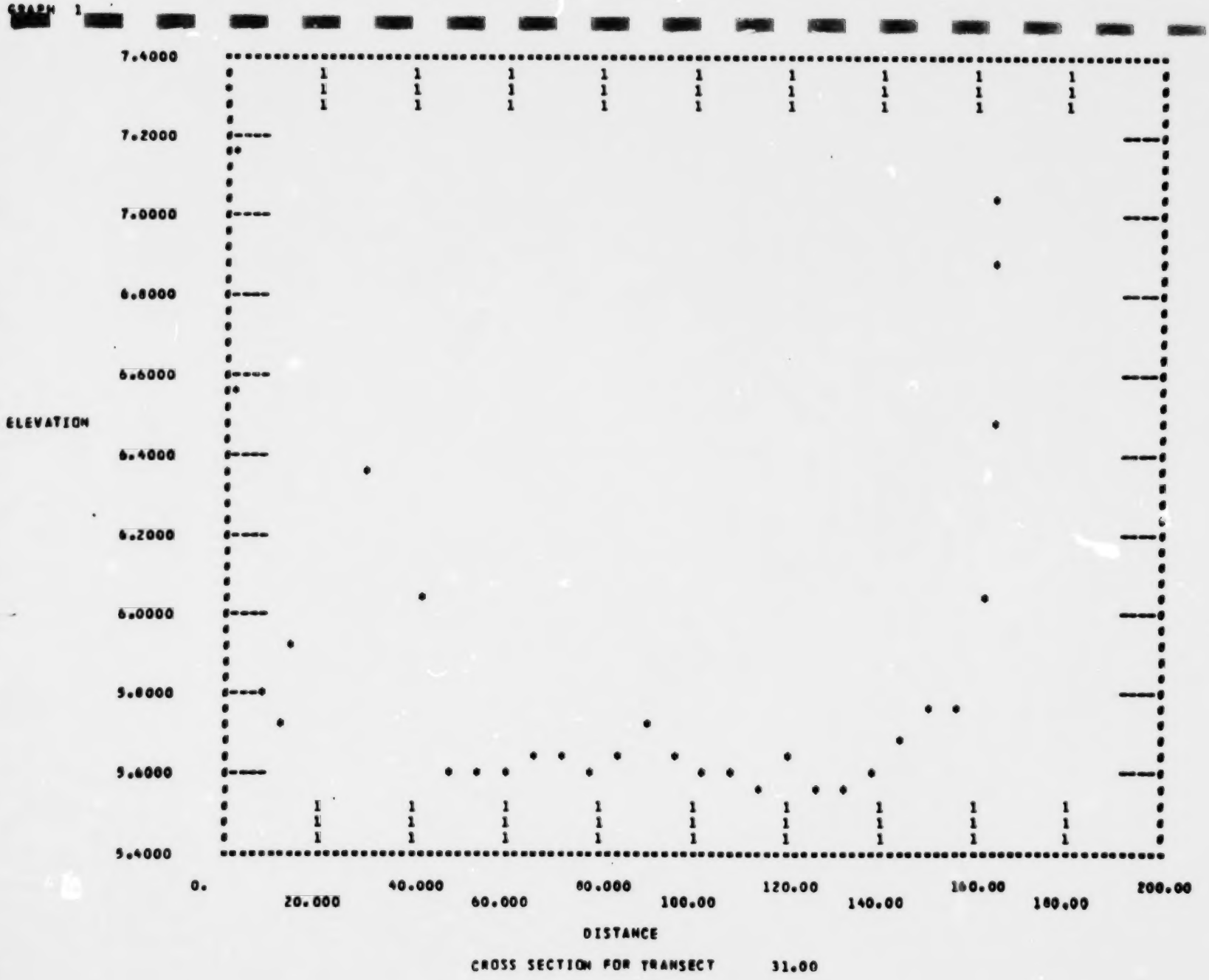
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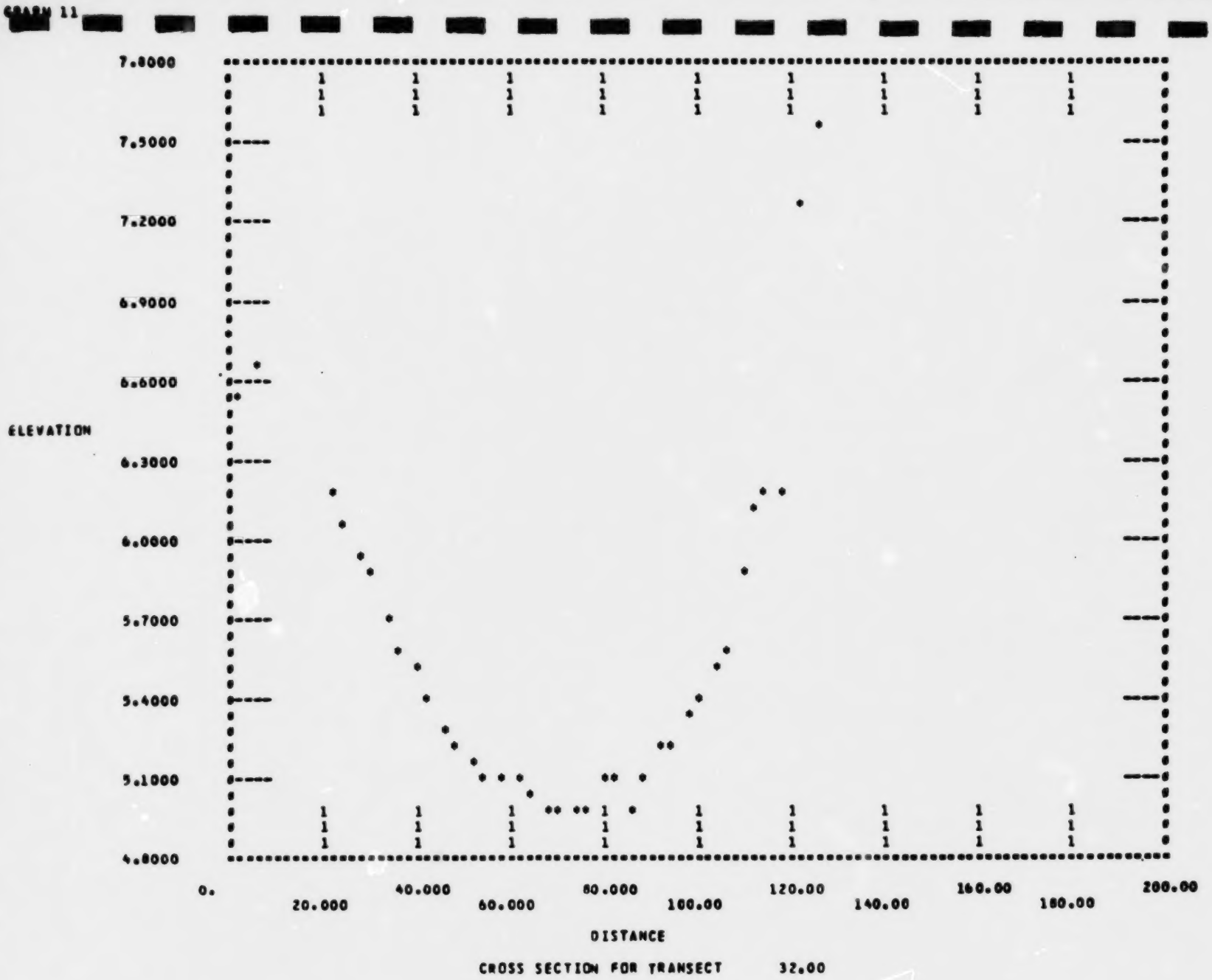
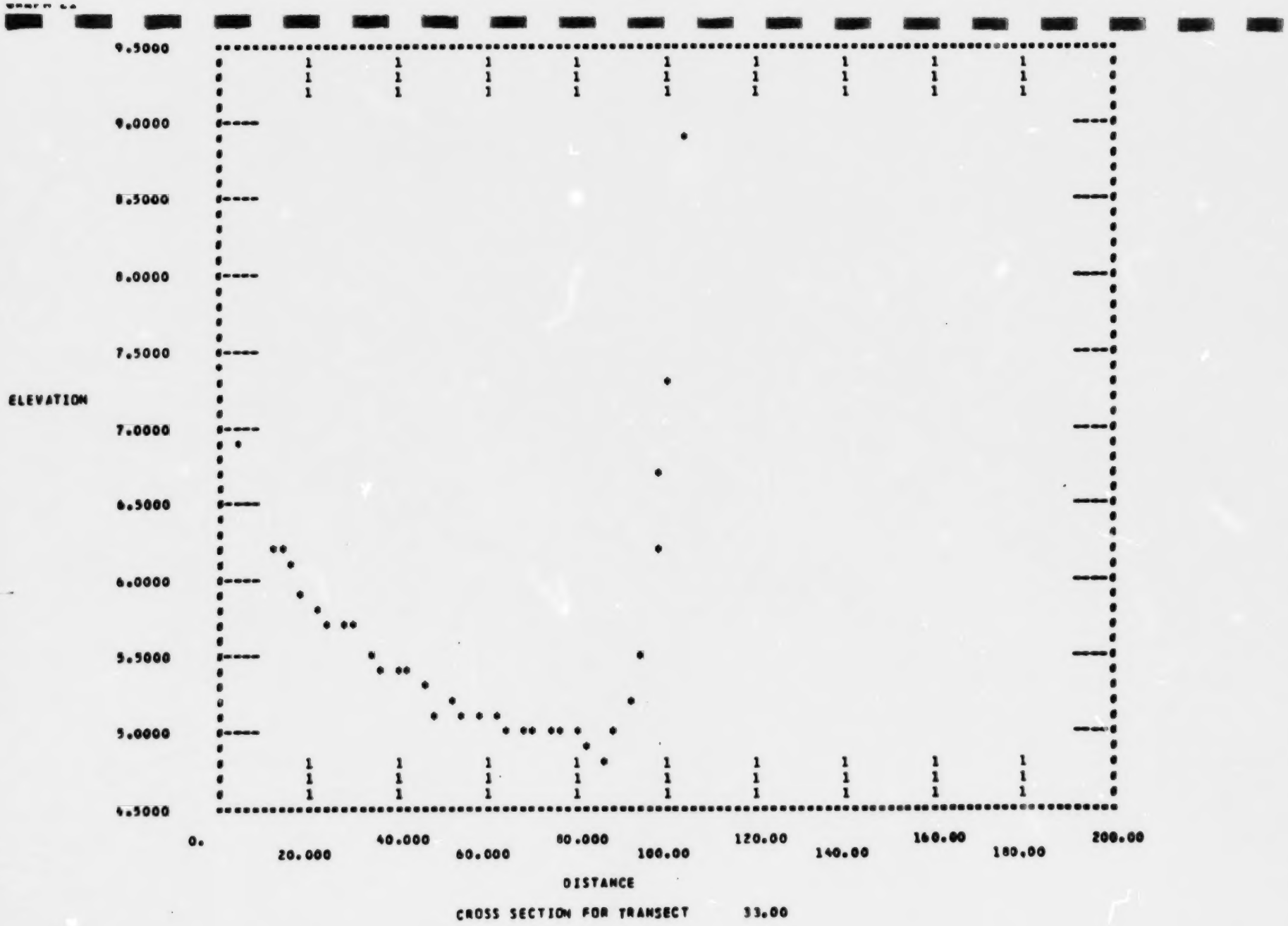
6.8000
6.6000
ELEVATION
6.4000
6.2000
6.0000
5.8000
5.6000
5.4000
0.
20.000
40.000
60.000
80.000
100.00
120.00
140.00
160.00
180.00
200.00
DISTANCE
CROSS SECTION FOR TRANSECT 31.00

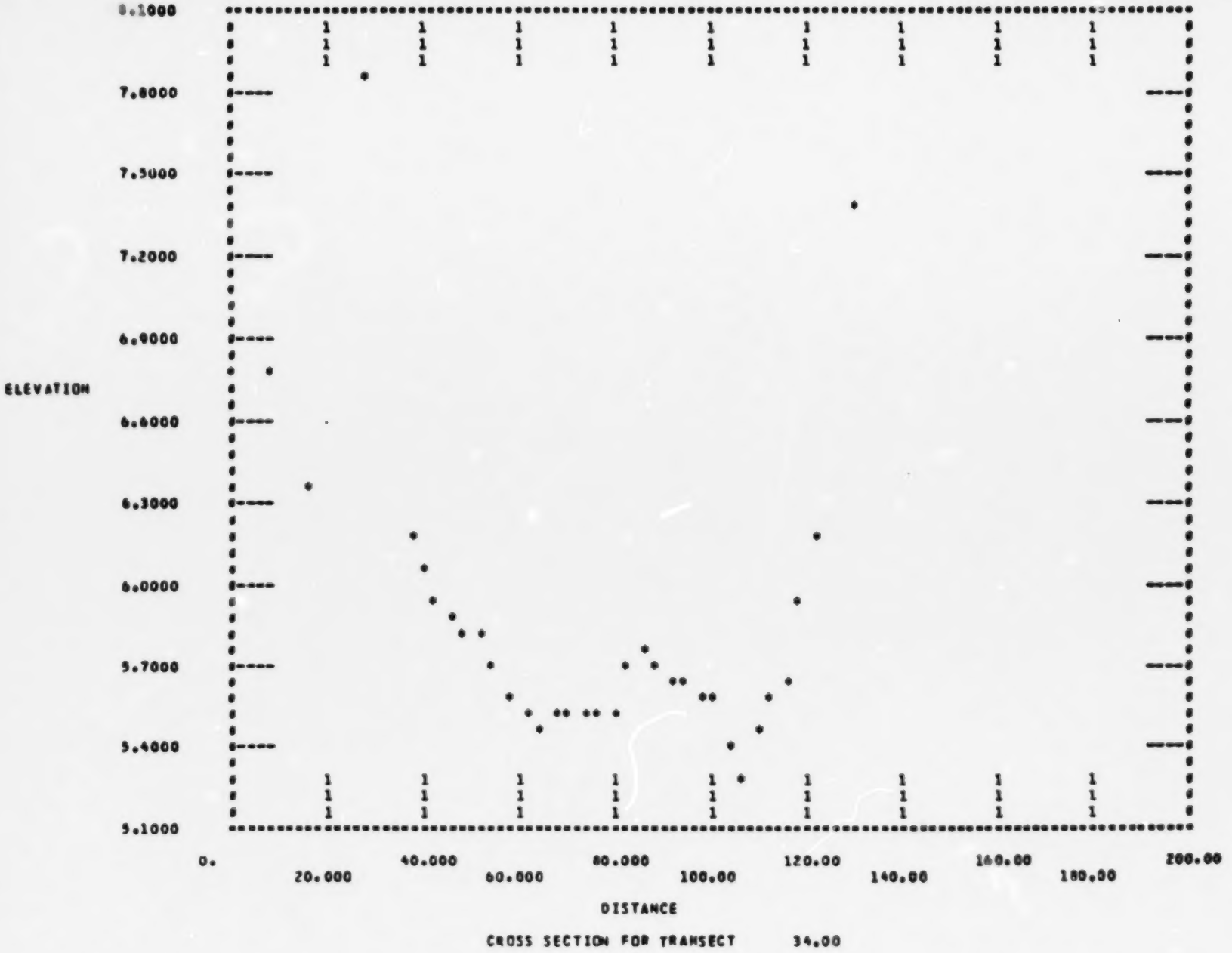


CROSS SECTION FOR TRANSECT 32.00



CROSS SECTION FOR TRANSECT 33.00

GRAPH 31



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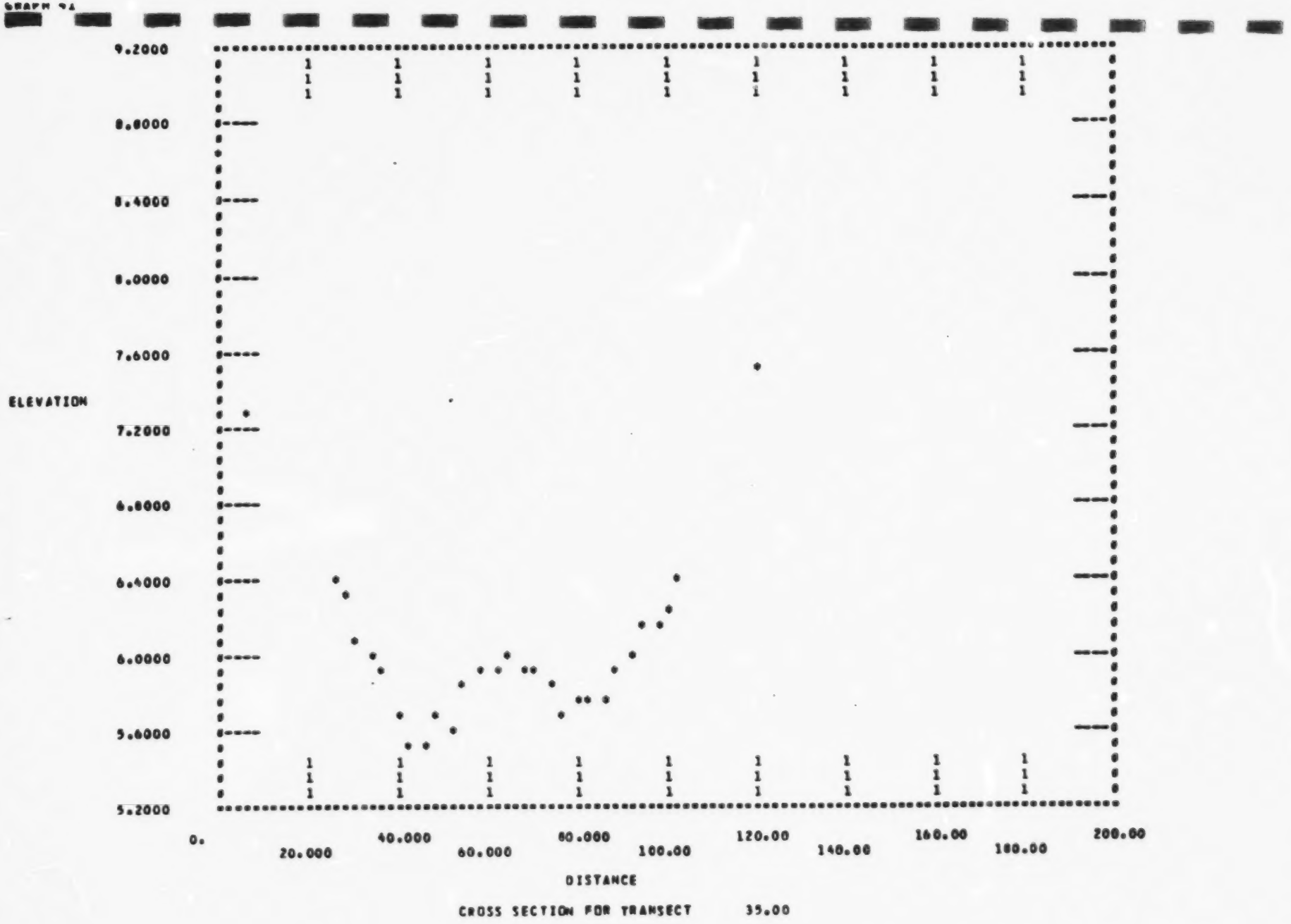

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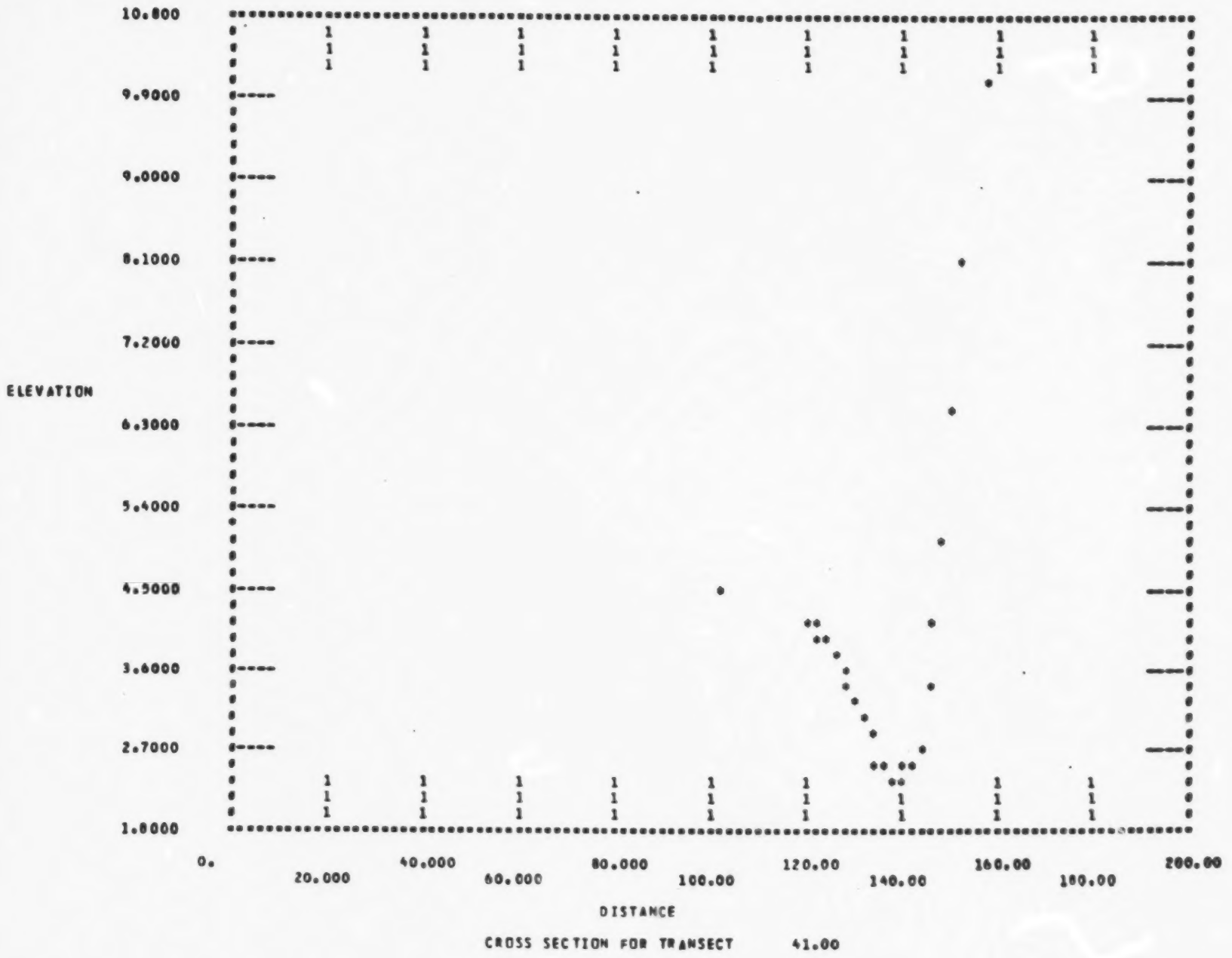
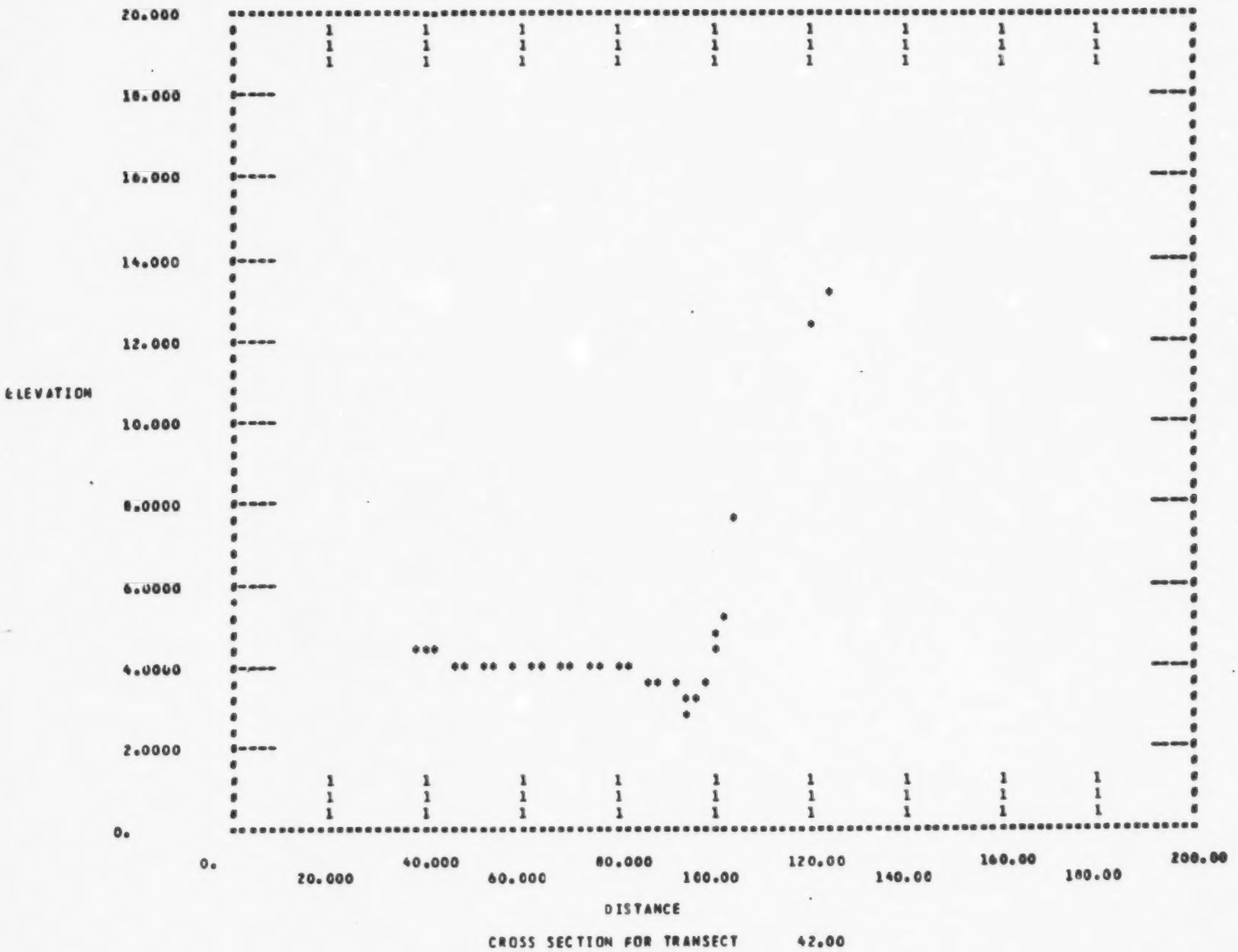


CROSS SECTION FOR TRANSECT 41.00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16.000
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ELEVATION
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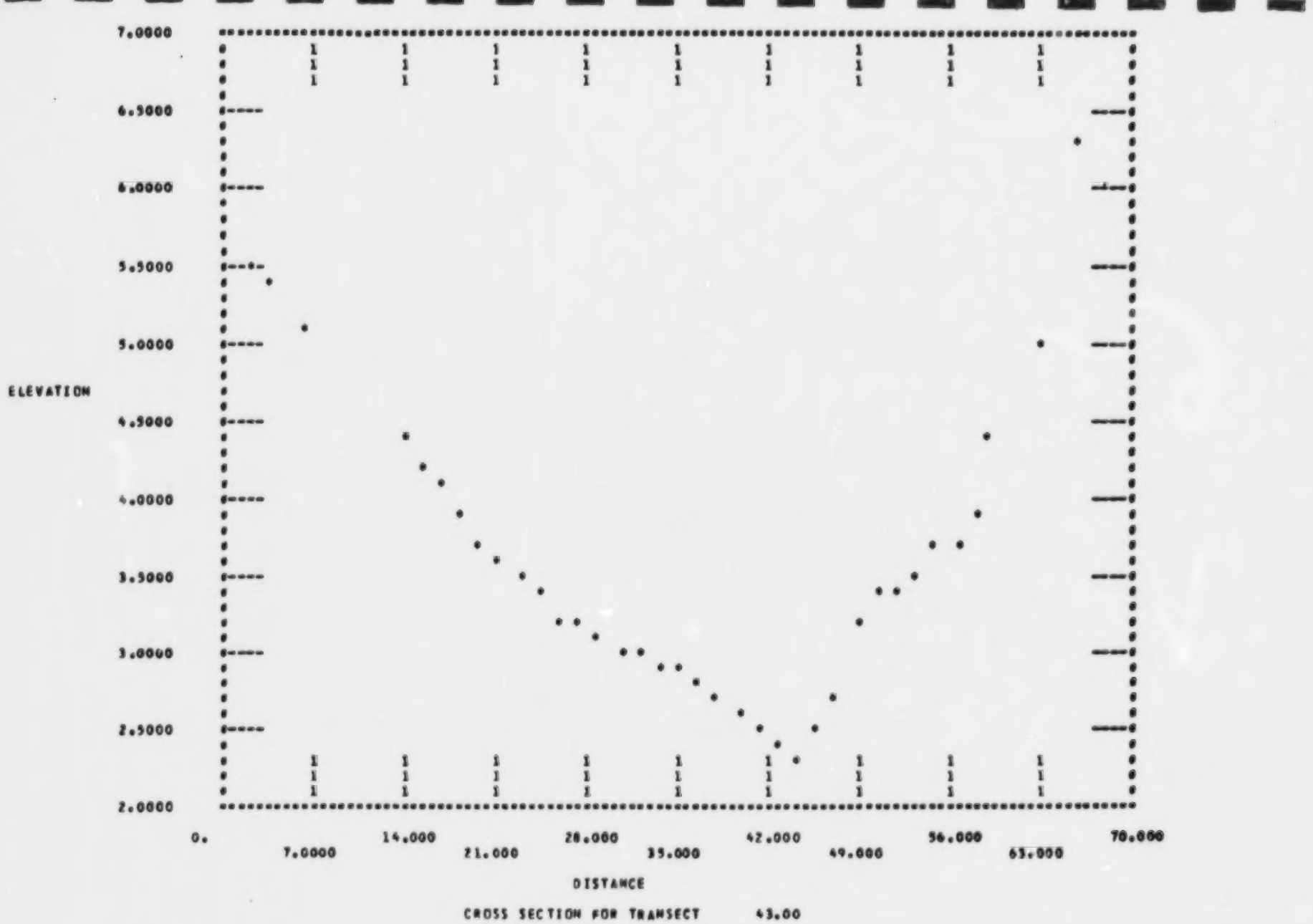
8.0000
6.0000
4.0000
2.0000
0.
0.
20.000
40.000
60.000
80.000
100.00
120.00
140.00
160.00
180.00
200.00
DISTANCE
CROSS SECTION FOR TRANSECT 42.00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4.5000
4.0000
3.5000
3.0000
2.5000
2.0000
ELEVATION
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7.0000
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21.000
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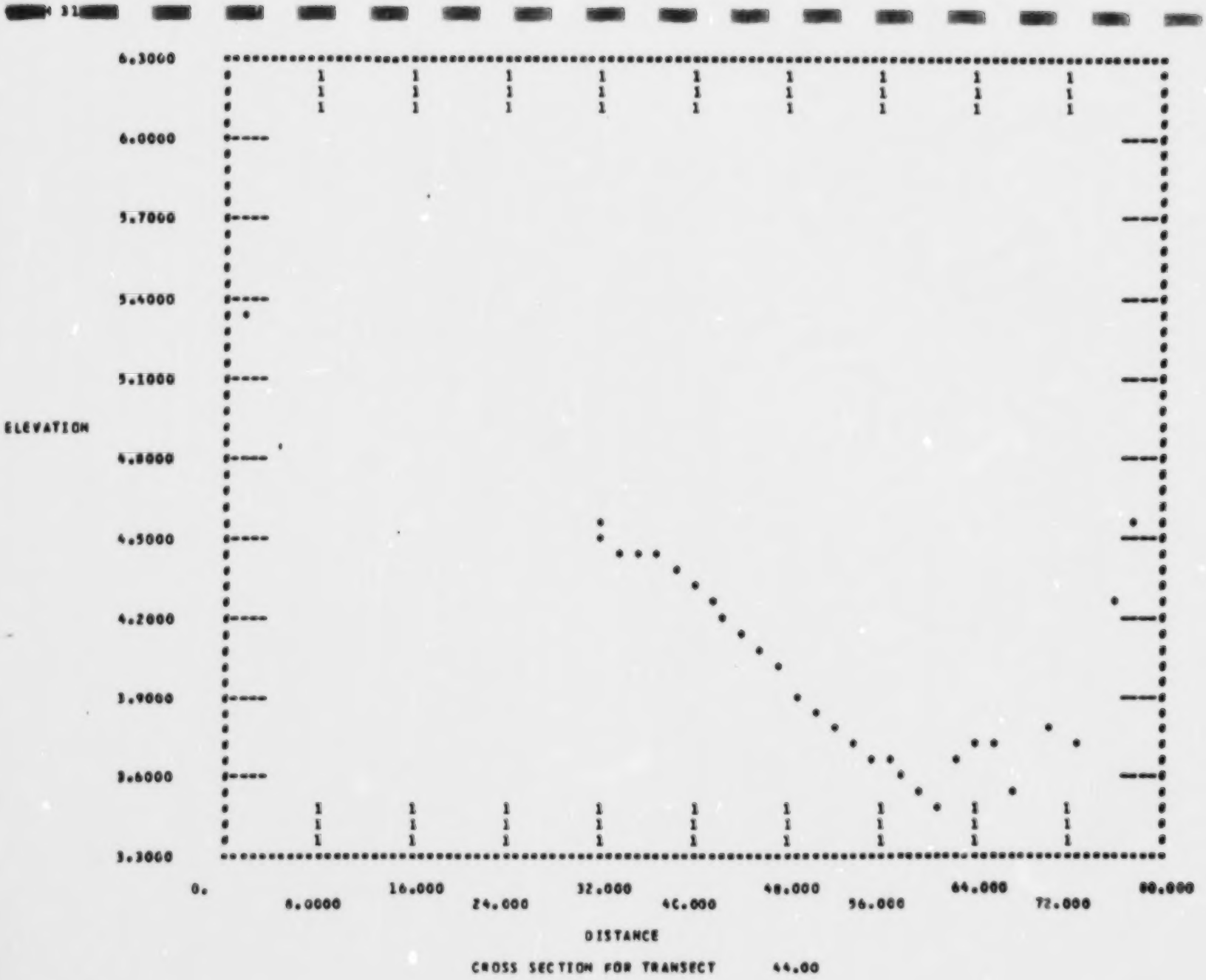
35.000
42.000
49.000
56.000
63.000
70.000
DISTANCE
CROSS SECTION FOR TRANSECT 43.00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3.3000
0.
8.0000
16.000
24.000
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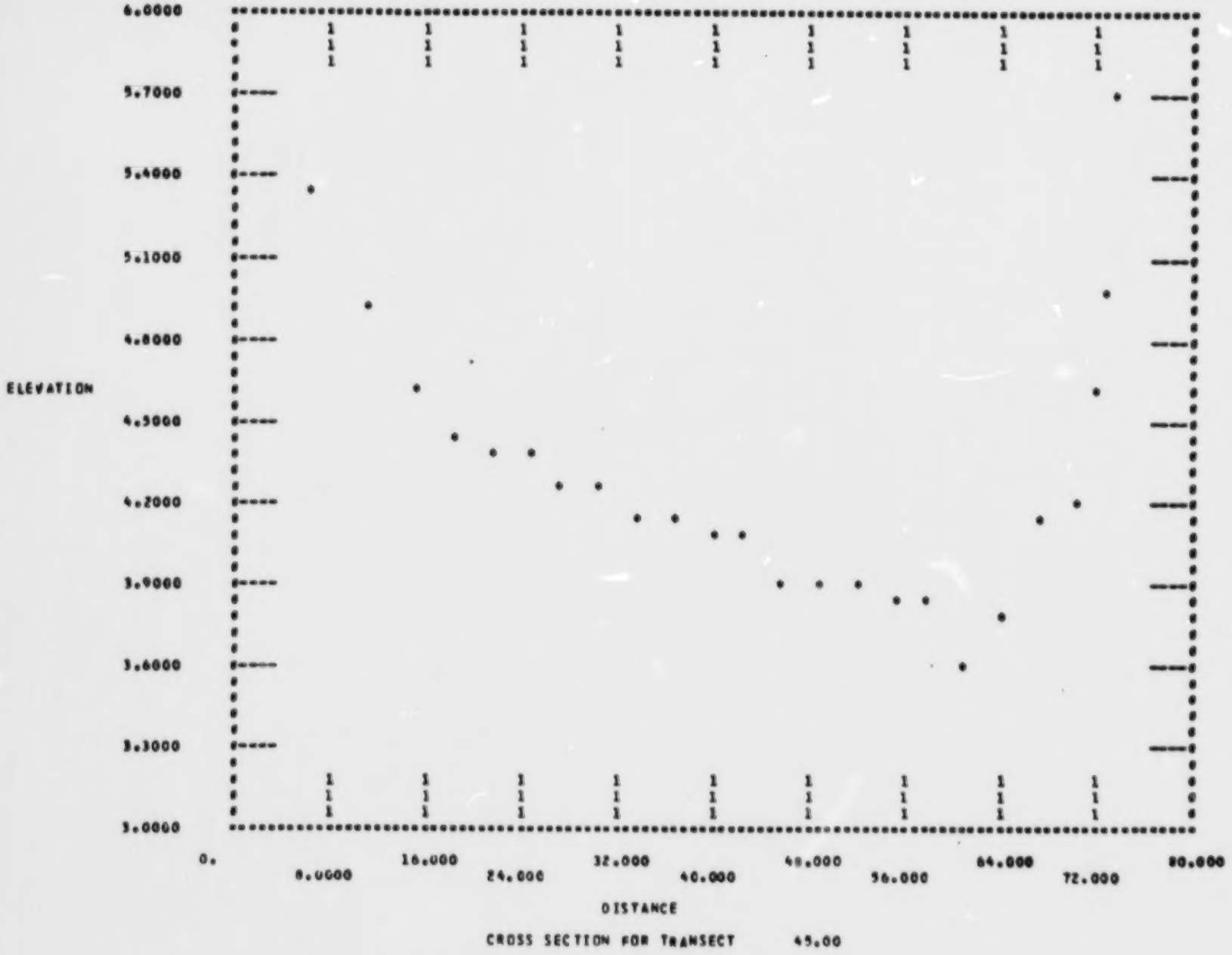
48.000
56.000
64.000
72.000
80.000
DISTANCE
CROSS SECTION FOR TRANSECT 44.00



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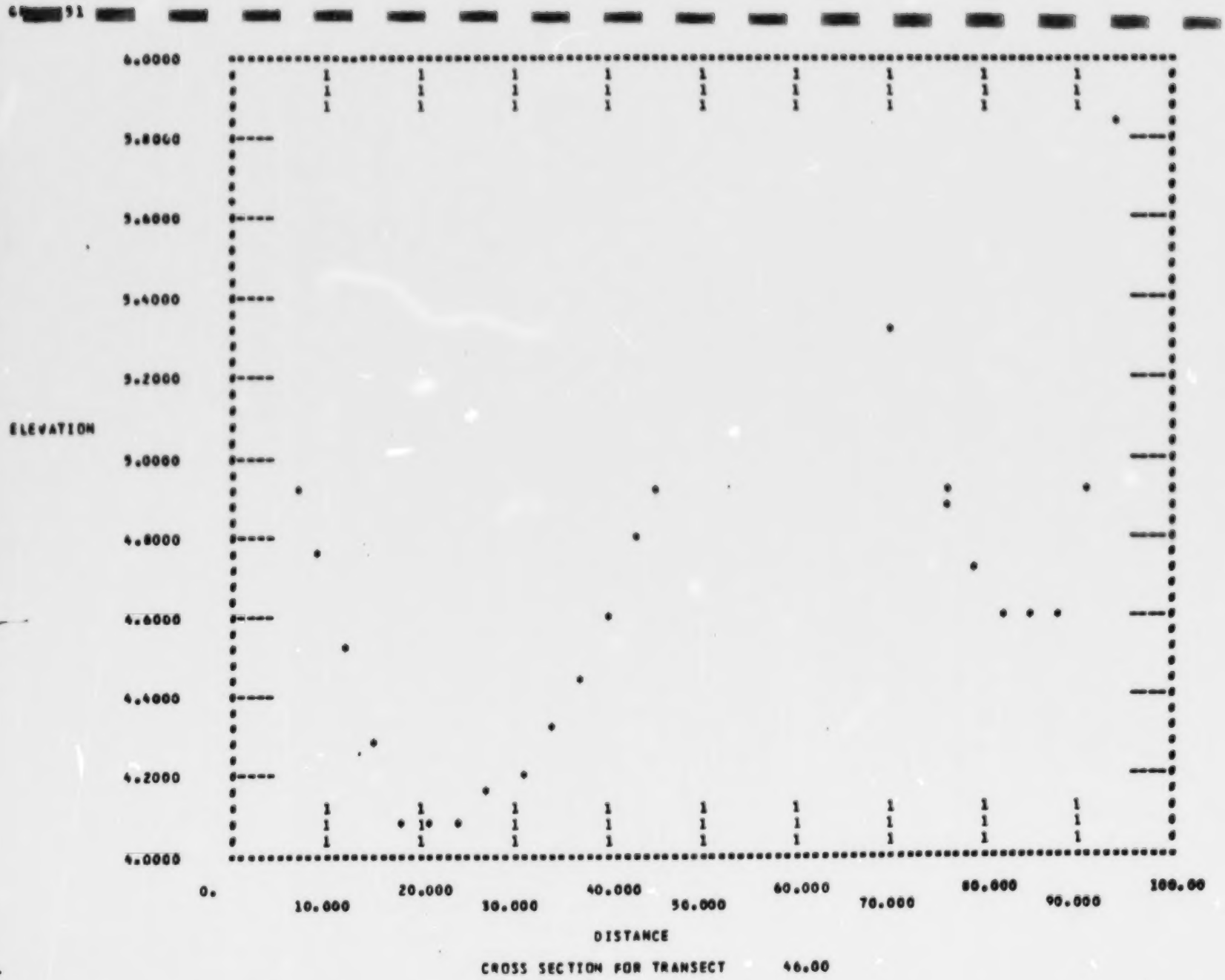
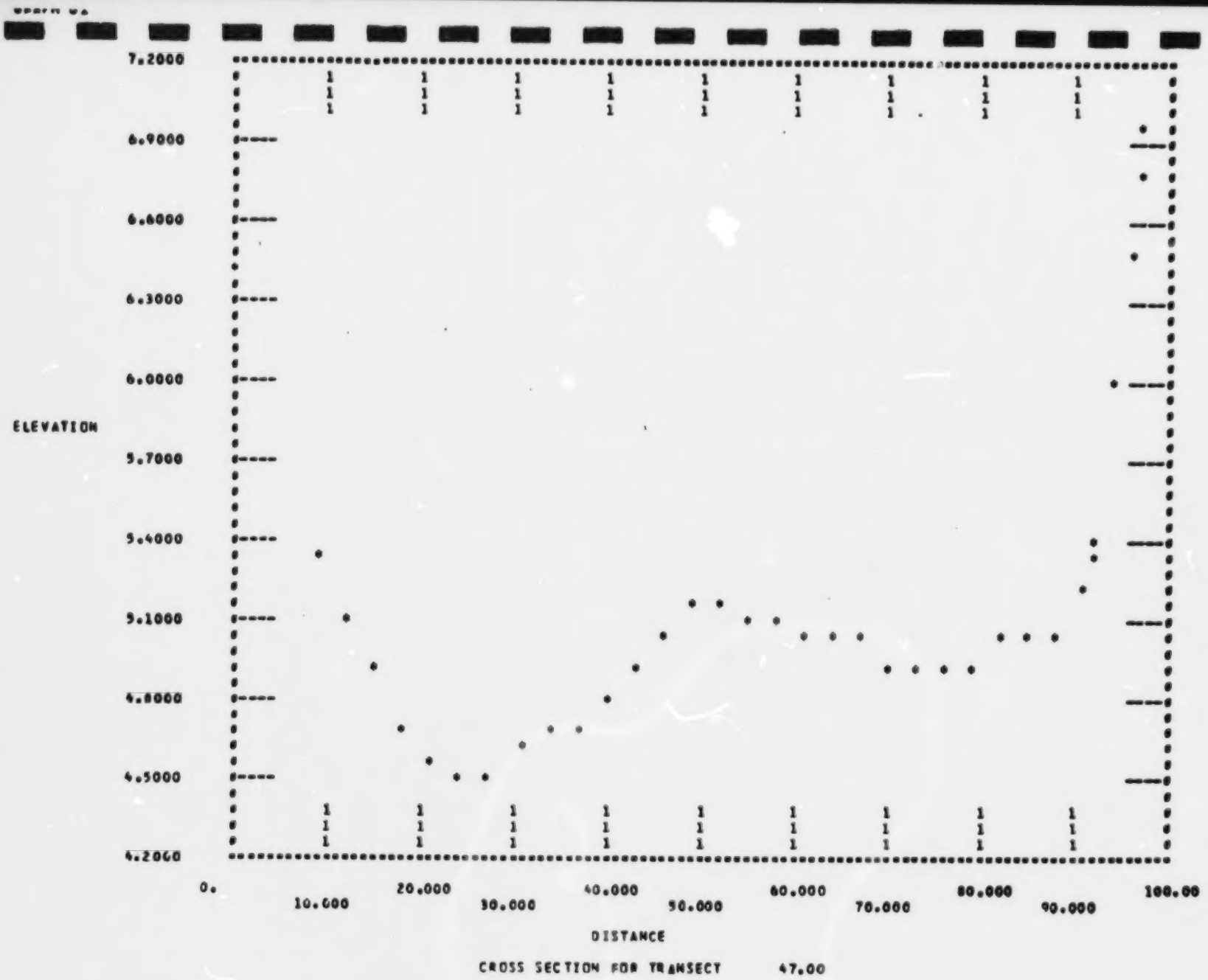


CROSS SECTION FOR TRANSECT 46.00



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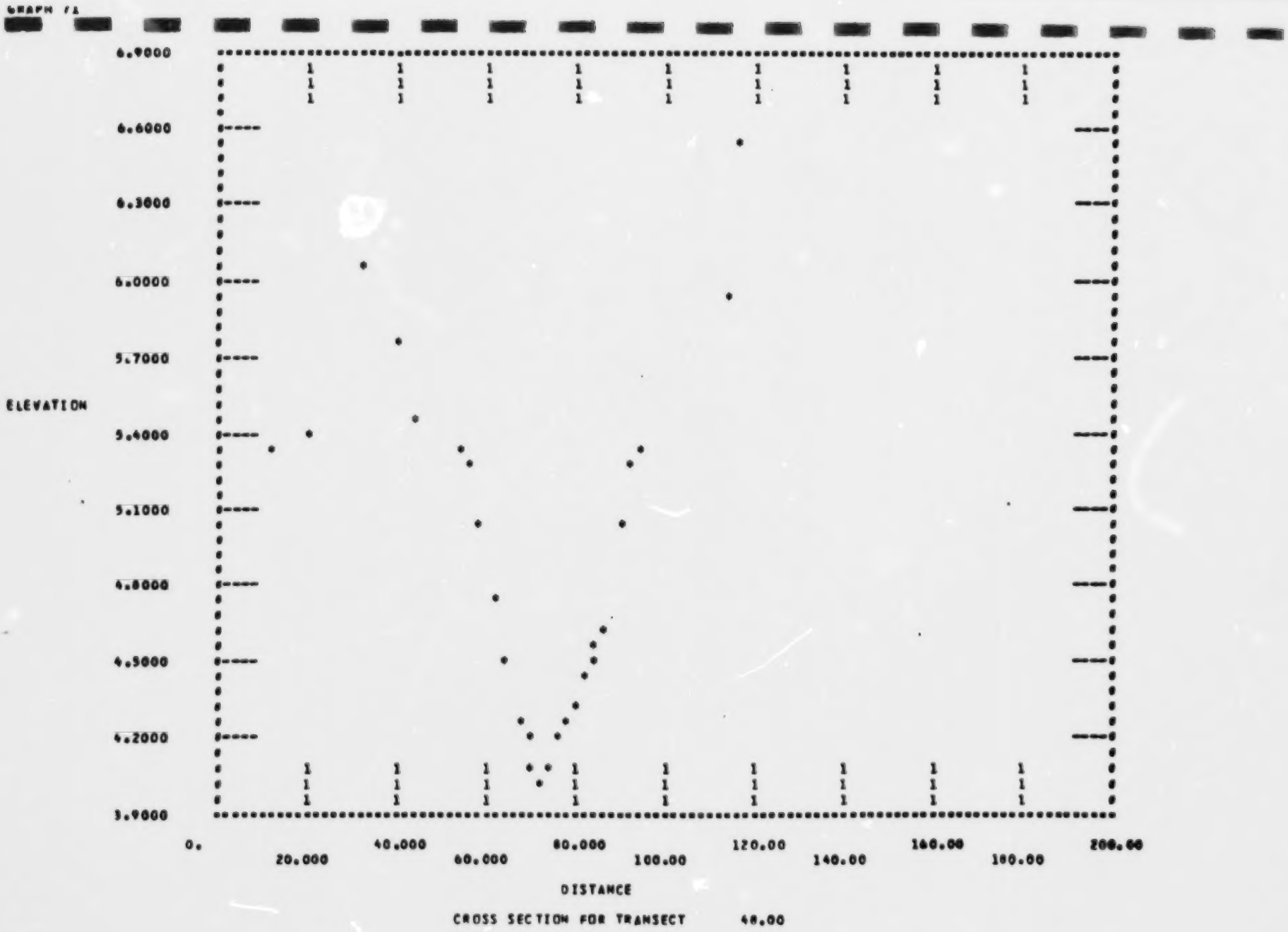
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3.9000
0.
20.000
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100.00
120.00
140.00
160.00
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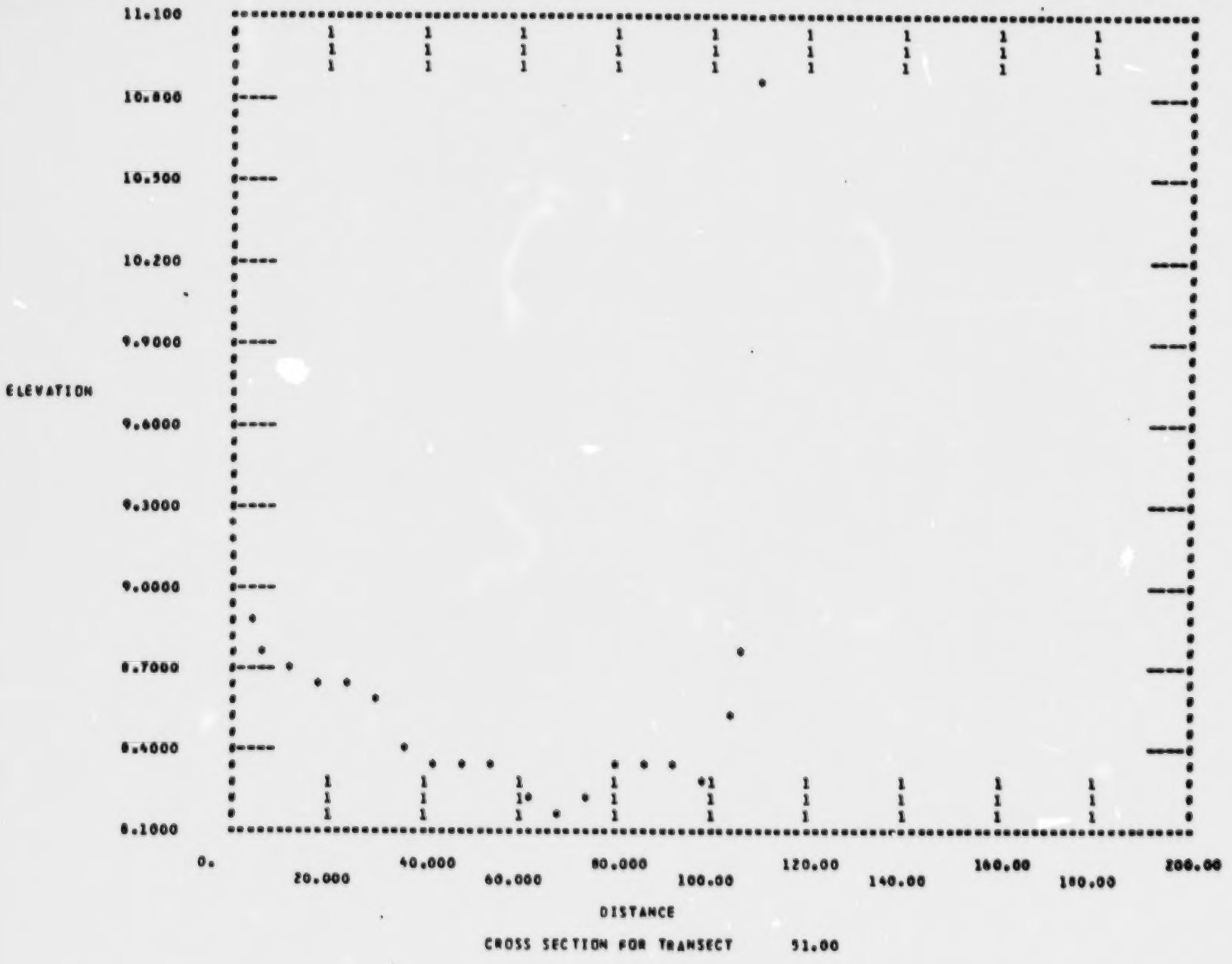
DISTANCE
CROSS SECTION FOR TRANSECT 40.00



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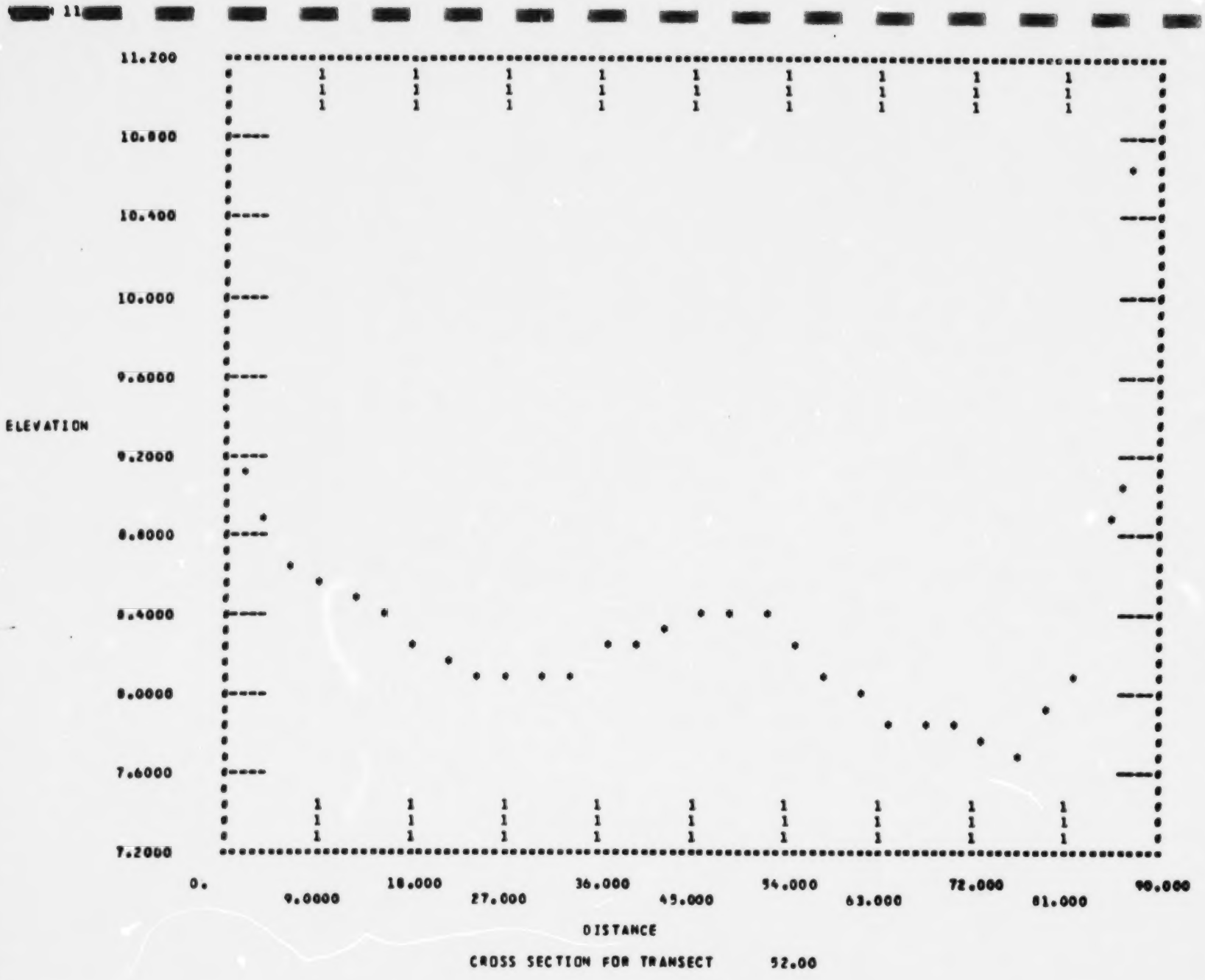

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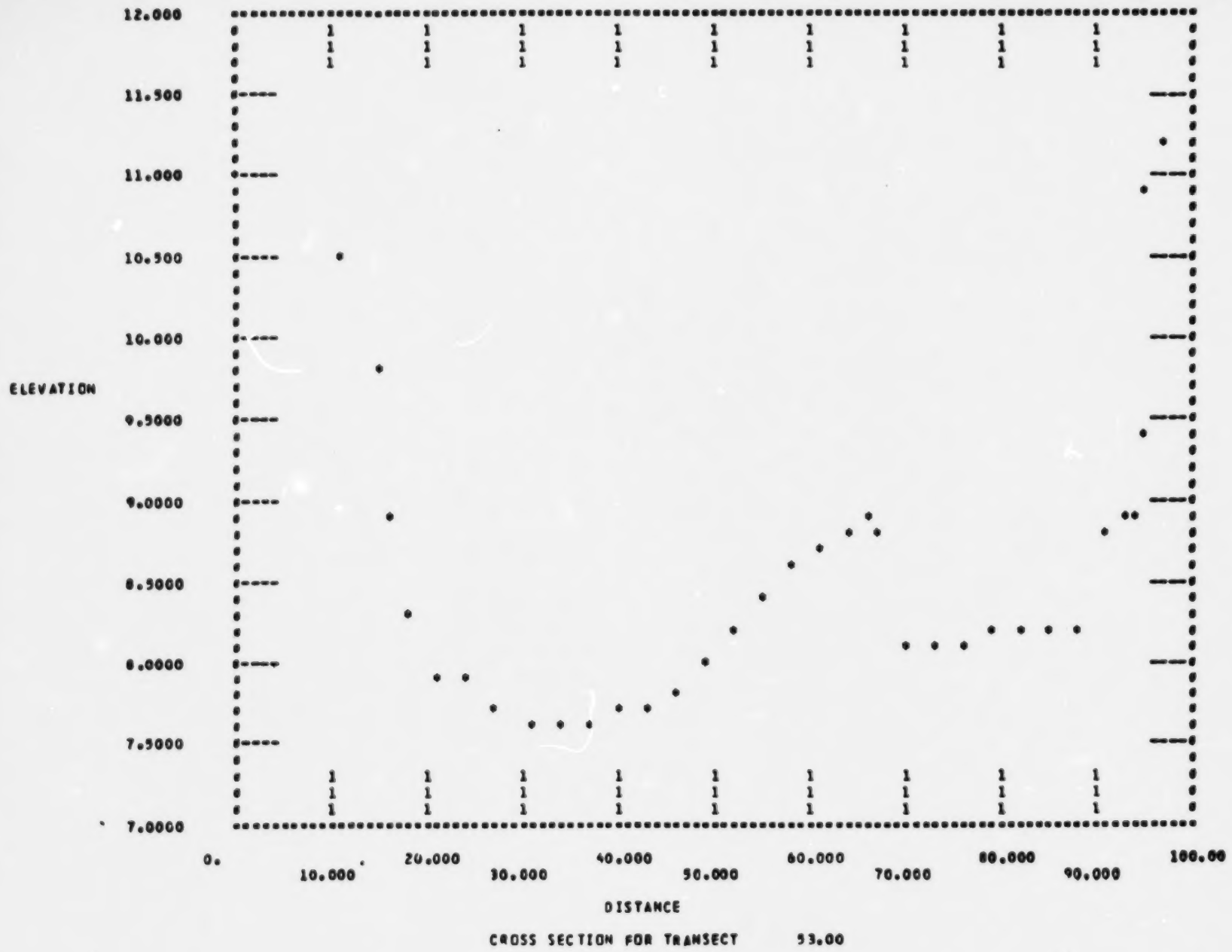

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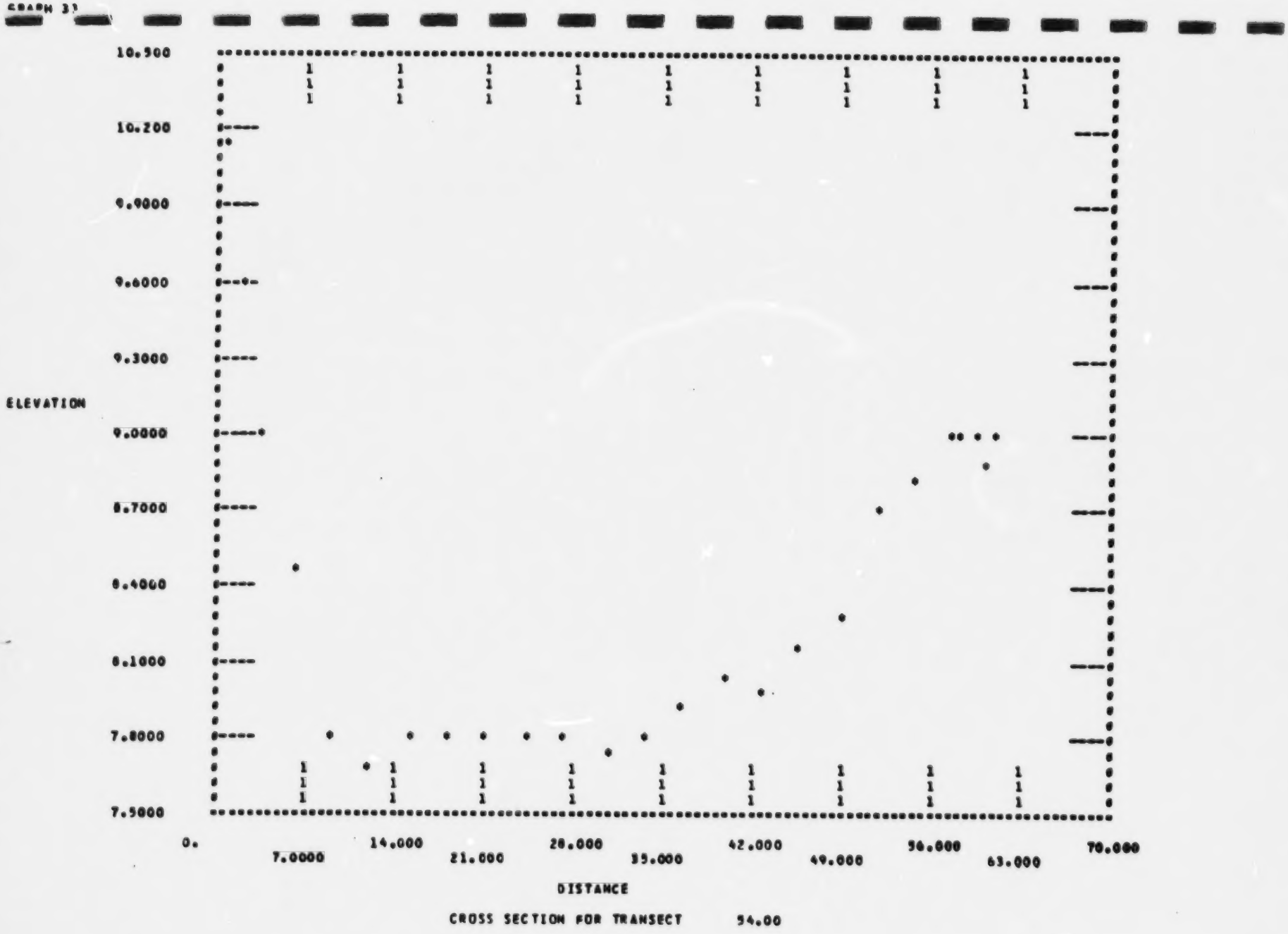
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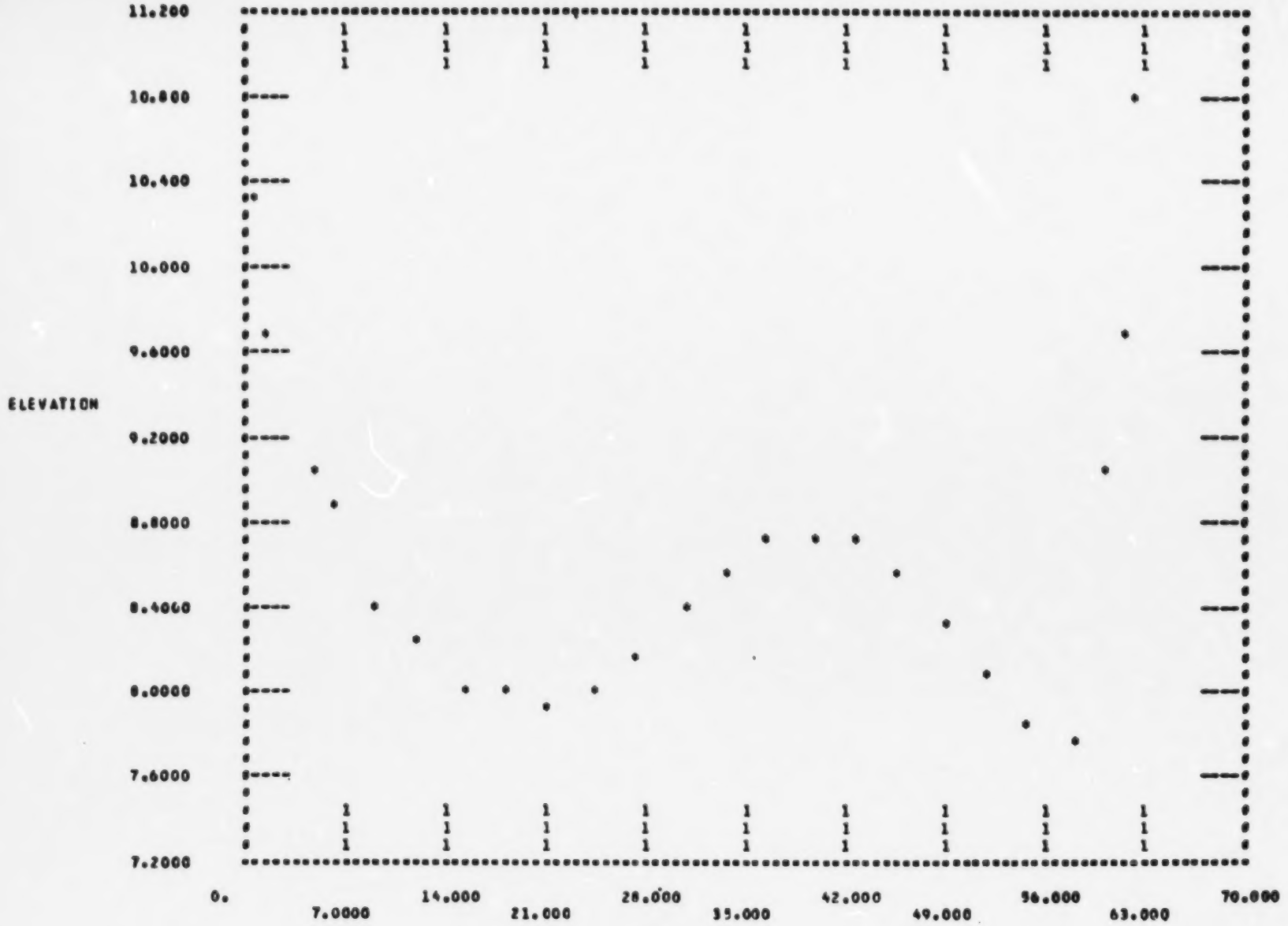
9.9000
9.6000
9.3000
ELEVATION
9.0000
8.7000
8.4000
8.1000
7.8000
7.5000
0.
7.0000
14.000
21.000
28.000
35.000
42.000
49.000
56.000
63.000
70.000
DISTANCE
CROSS SECTION FOR TRANSECT 54.00



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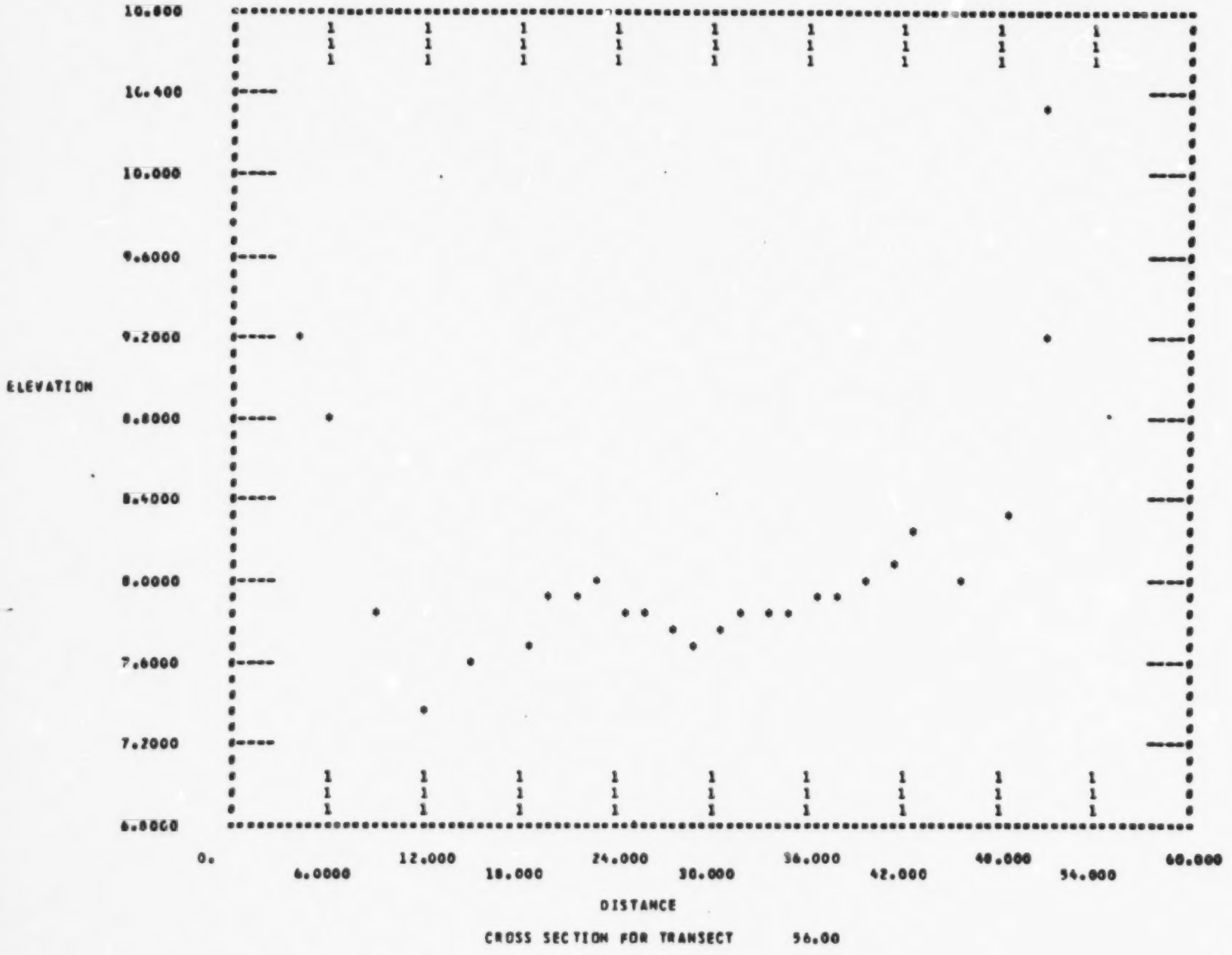

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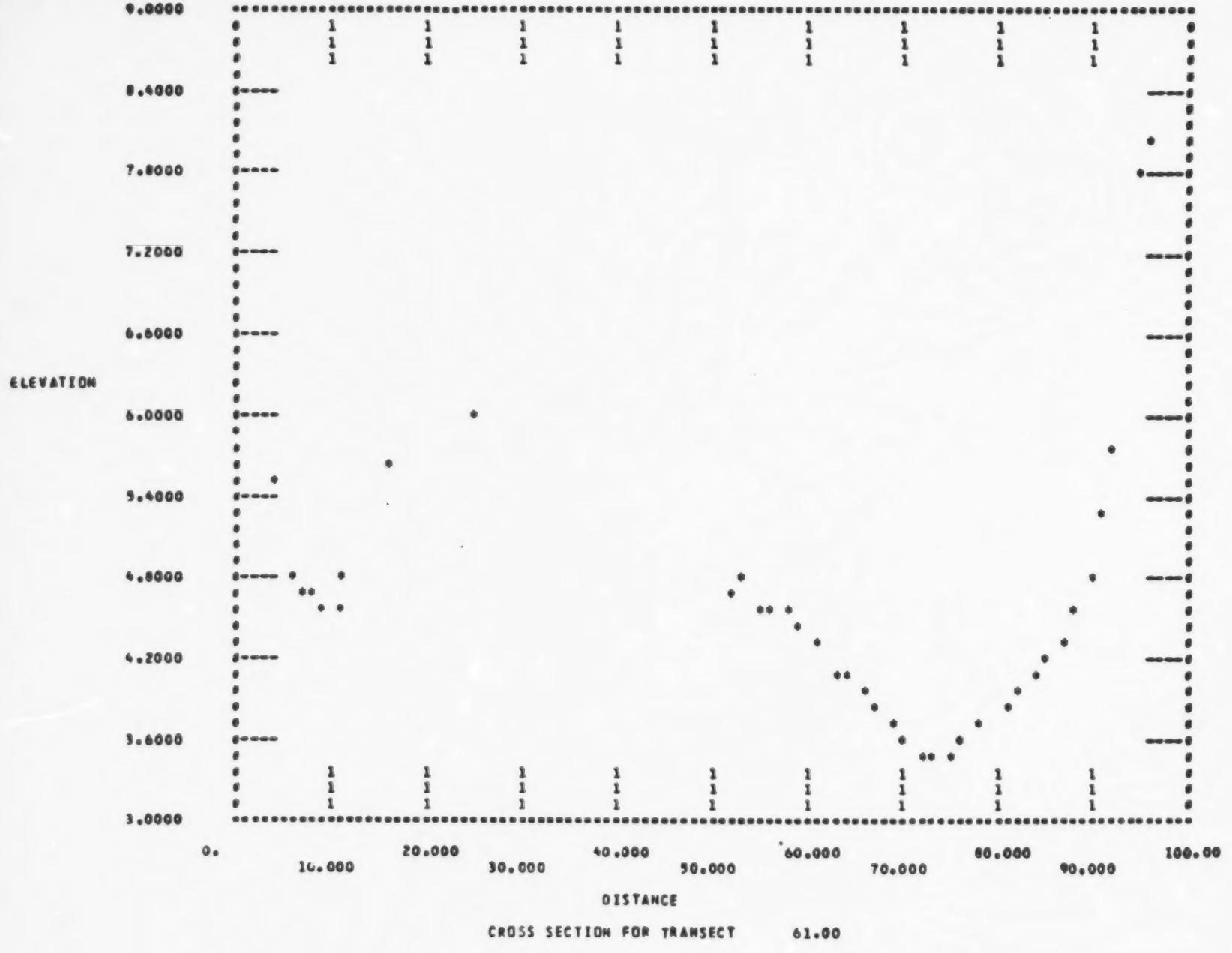
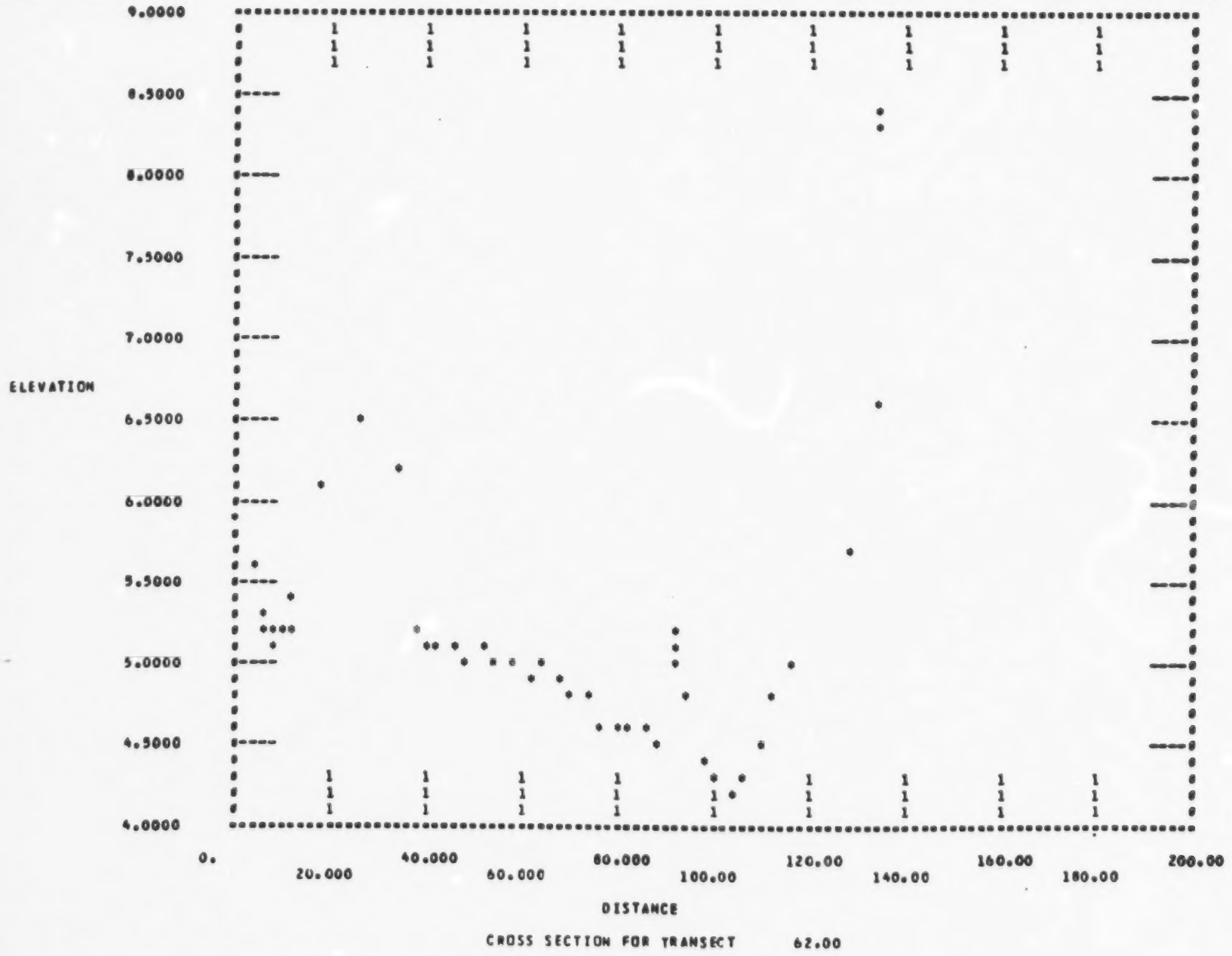


CROSS SECTION FOR TRANSECT 61.00

GRAPH 11



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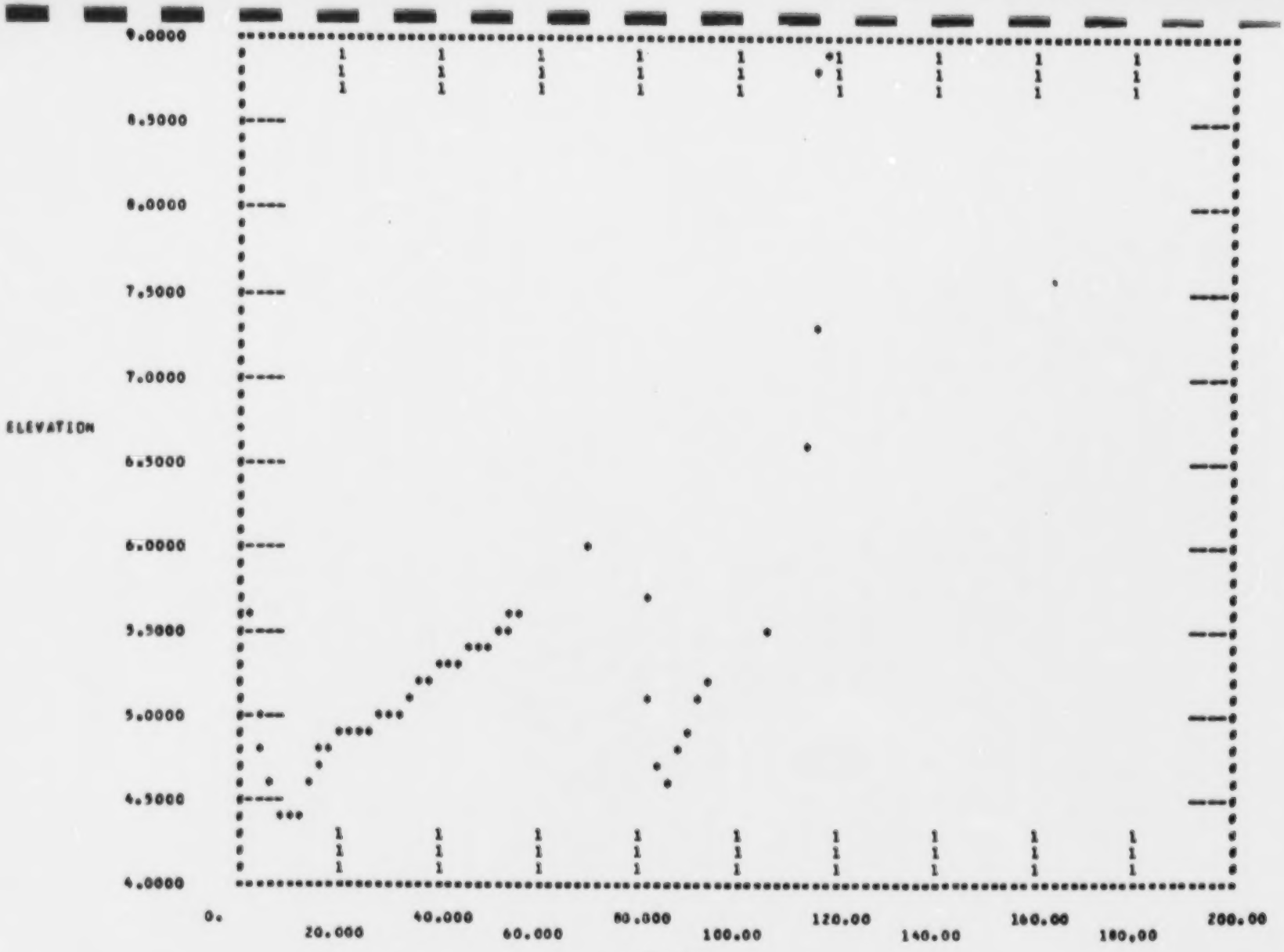
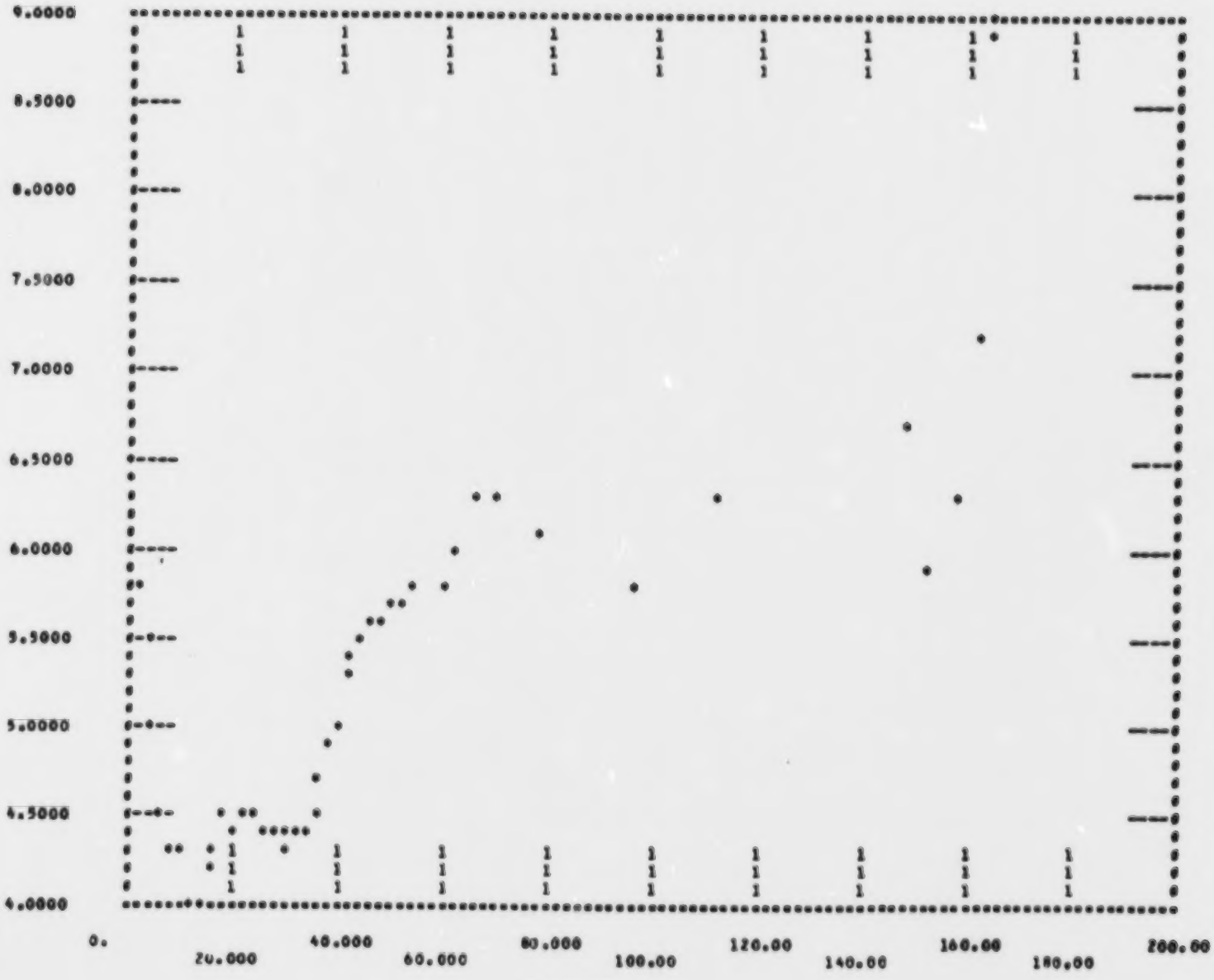


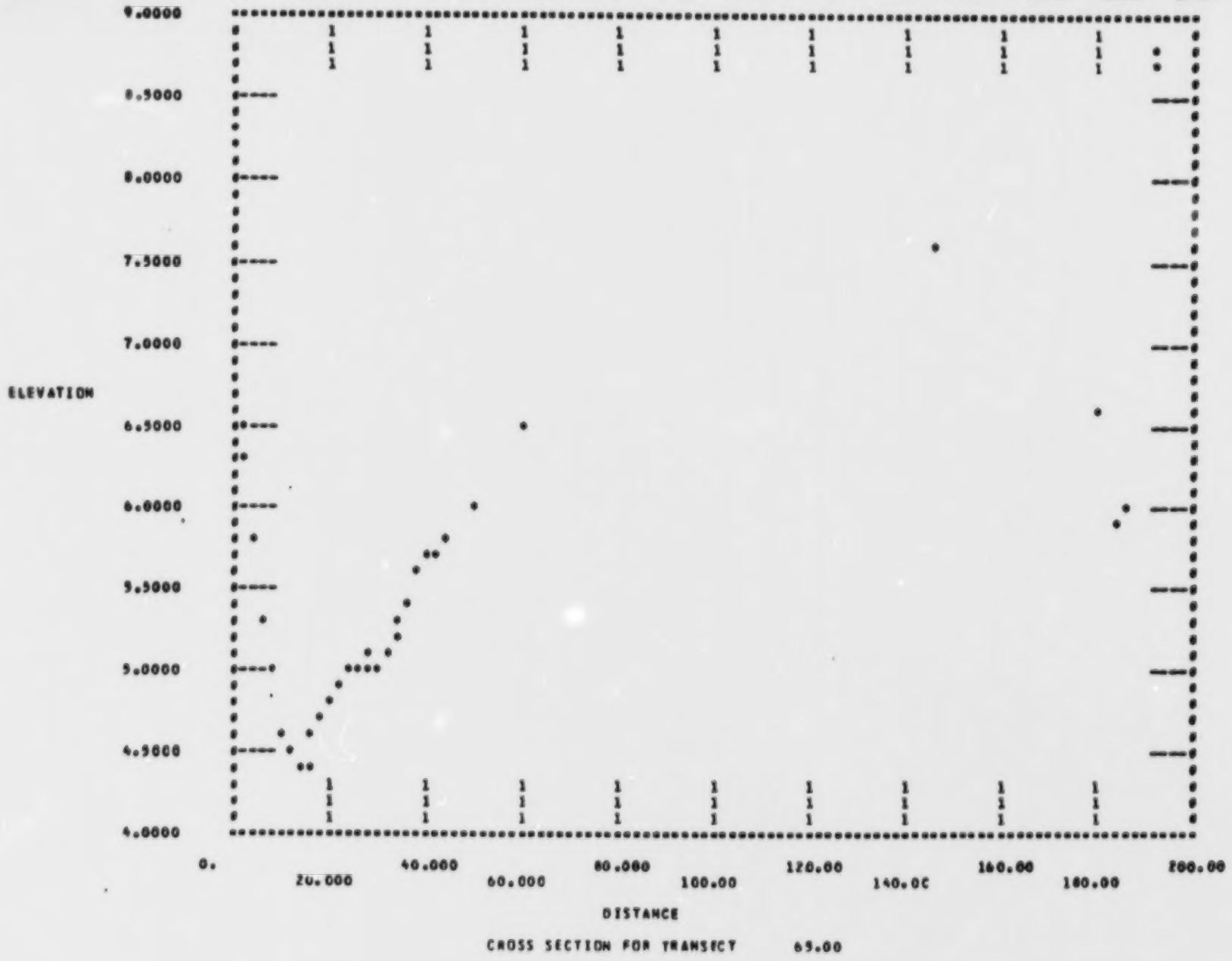
CROSS SECTION FOR TRANSECT 63.00

GRAPH 31



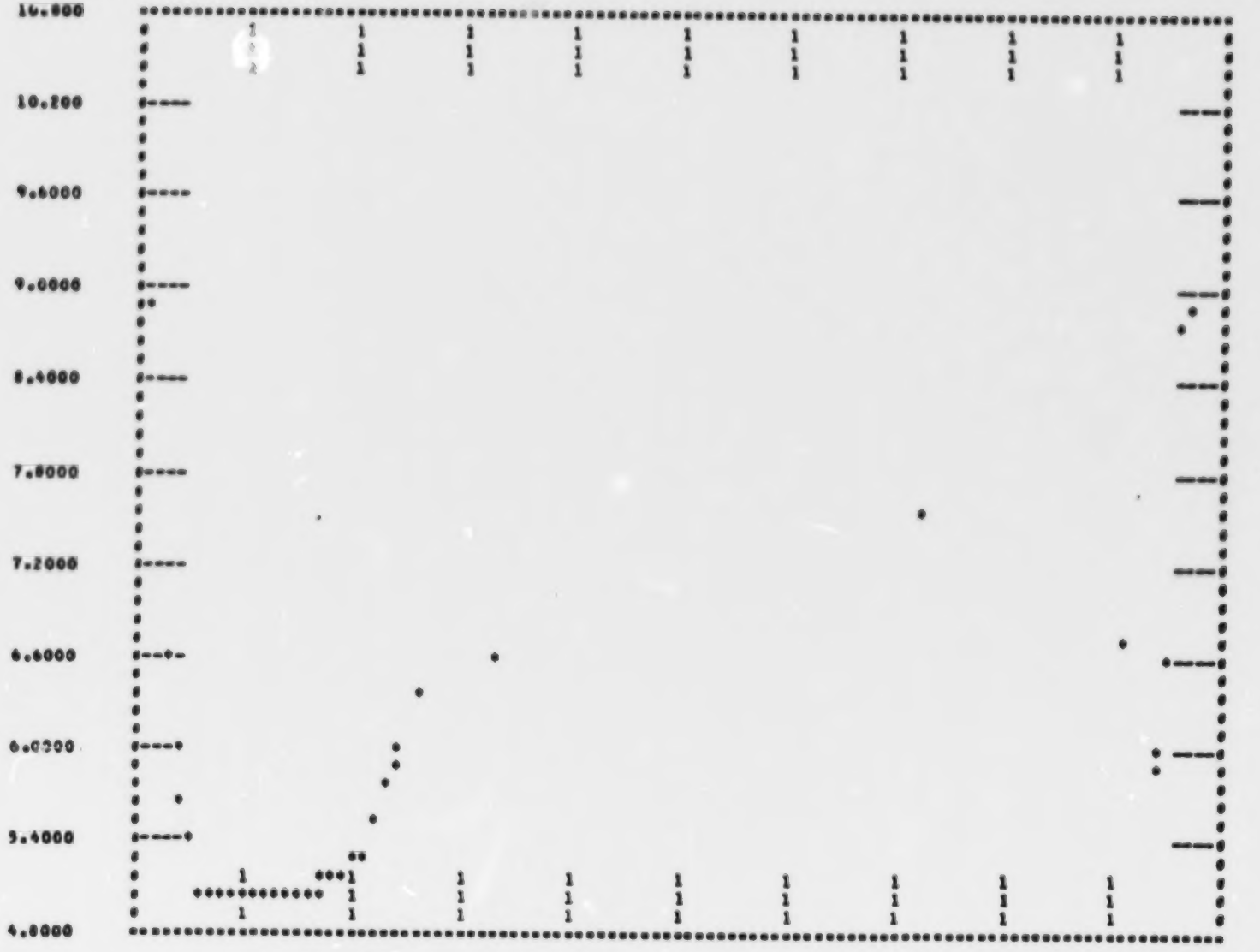
CROSS SECTION FOR TRANSECT 64.00

GRAPH 41

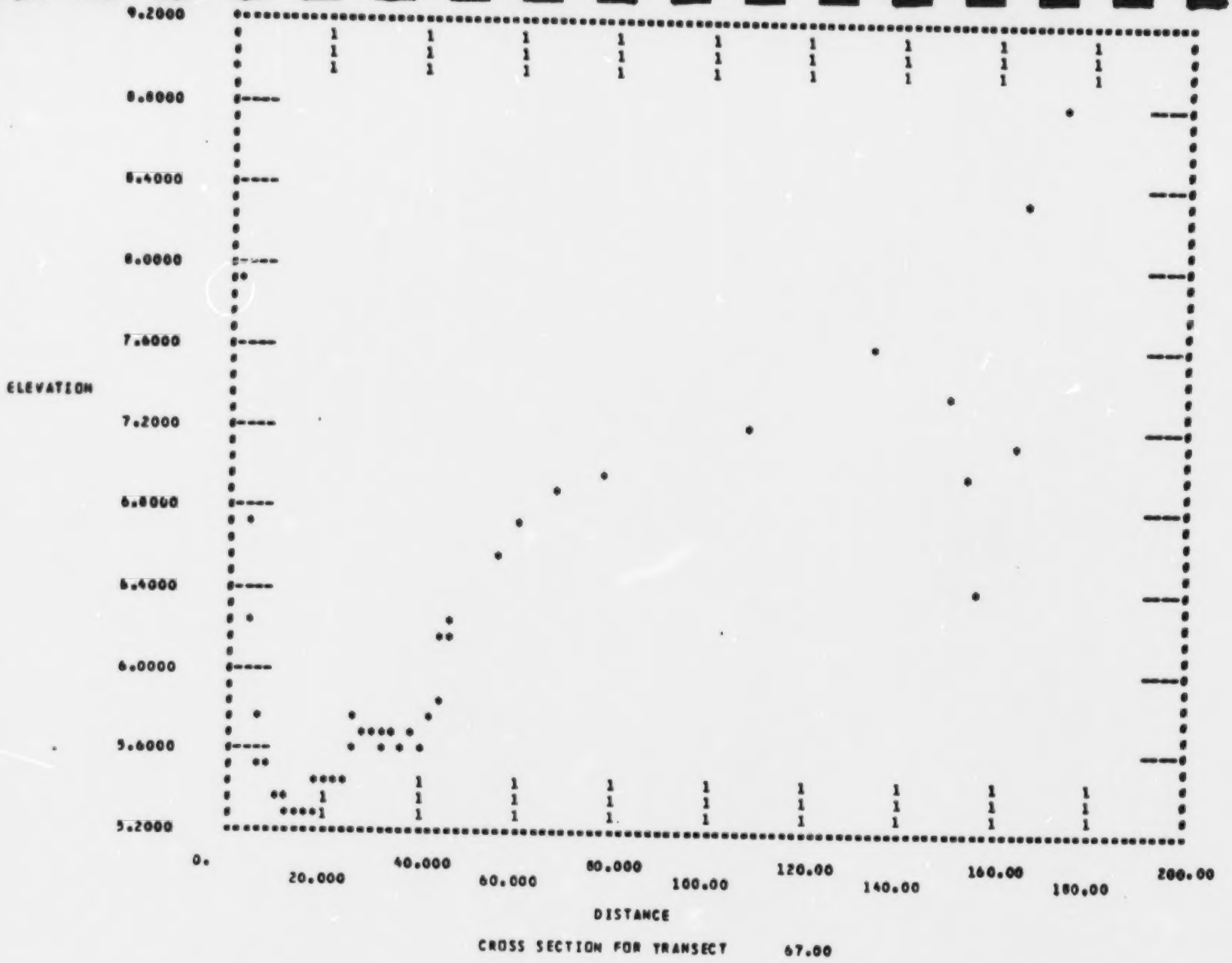


CROSS SECTION FOR TRANSECT 69.00

GRAPH 91



CROSS SECTION FOR TRANSECT 66.00



CROSS SECTION FOR TRANSECT 67.00

PART III

HABITAT MEASUREMENTS AT FISH OBSERVATION LOCATIONS

TABLE II-1

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
4	7/ 7/85	.34	0.53	5.60	1	OS
5	8/ 7/85	.49	0.64	5.56	1	OS
5	8/ 7/85	1.25	0.58	6.65	1	OS
5	8/ 7/85	.85	1.61	5.70	2	OS
5	8/ 7/85	.64	1.09	6.60	1	OS
6	9/ 7/85	.88	1.29	6.25	1	OS
6	9/ 7/85	.76	1.15	6.30	1	OS
6	9/ 7/85	.71	0.88	6.35	1	OS
6	10/ 7/85	.84	0.42	6.40	1	OS
6	10/ 7/85	.66	1.01	6.50	1	OS
6	11/ 7/85	1.10	0.74	6.70	1	OS
6	11/ 7/85	1.28	0.69	6.92	1	OS
6	11/ 7/85	1.34	1.42	7.40	1	OS
6	11/ 7/85	1.28	0.73	7.05	1	OS
6	12/ 7/85	1.17	0.83	6.50	1	OS
6	12/ 7/85	.95	1.28	5.25	2	OS
6	12/ 7/85	.85	1.20	6.15	1	OS
6	12/ 7/85	.82	1.07	6.45	1	OS
6	12/ 7/85	.98	0.84	8.15	1	OS
6	12/ 7/85	.85	0.37	6.65	1	OS
6	12/ 7/85	1.16	0.86	5.70	2	OS
6	14/ 7/85	1.62	0.75	8.70	2	OS
6	14/ 7/85	2.13	0.81	6.90	1	OS
4	24/ 7/85	.52	0.06	4.61	1	OS
4	24/ 7/85	.51	0.61	4.50	1	OS
4	24/ 7/85	.68	0.55	5.00	1	OS
2	25/ 7/85	.58	0.21	4.60	7	OS
2	25/ 7/85	.68	0.54	5.55	2	OS
3	26/ 7/85	.84	0.26	5.30	5	OS
3	26/ 7/85	.86	0.34	4.75	1	OS
3	26/ 7/85	.99	0.39	4.25	2	OS
2	28/ 7/85	.46	0.51	5.65	1	OS
2	28/ 7/85	.44	0.72	5.80	4	OS
2	28/ 7/85	.46	0.81	5.95	2	OS
2	28/ 7/85	.34	0.47	5.70	1	OS
2	28/ 7/85	.55	0.21	6.15	2	OS
2	28/ 7/85	.55	0.46	6.25	3	OS
2	28/ 7/85	.48	0.42	6.10	2	OS
2	28/ 7/85	.50	0.27	5.05	1	OS
2	28/ 7/85	.42	0.48	6.65	4	OS
2	28/ 7/85	.32	0.58	5.75	1	OS

TABLE II-1

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
2	28/ 7/85	.56	0.23	5.87	1	OS
2	28/ 7/85	.44	0.36	6.30	1	OS
2	28/ 7/85	.18	0.79	6.43	10	OS
2	28/ 7/85	.52	0.50	6.68	4	OS
2	28/ 7/85	.50	0.85	6.15	6	OS
2	28/ 7/85	.60	0.22	5.00	3	OS
2	28/ 7/85	.38	0.72	6.40	2	OS
2	28/ 7/85	.49	0.56	6.23	1	OS
2	28/ 7/85	.47	0.72	6.15	2	OS
2	29/ 7/85	.65	0.30	5.55	1	OS
2	29/ 7/85	.64	0.65	5.95	3	OS
2	29/ 7/85	.58	0.29	5.95	1	OS
2	29/ 7/85	1.16	0.15	9.63	7	OS
2	29/ 7/85	1.03	0.34	5.89	4	OS
2	29/ 7/85	.70	0.29	5.48	2	OS
2	29/ 7/85	1.17	0.28	6.03	3	OS
2	29/ 7/85	.88	0.10	5.80	2	OS
2	29/ 7/85	.64	0.42	5.70	1	OS
2	29/ 7/85	.60	0.51	5.20	1	OS
2	29/ 7/85	.60	0.46	5.15	2	OS
2	29/ 7/85	.44	0.43	4.90	1	OS
2	29/ 7/85	.74	0.28	5.05	3	OS
2	29/ 7/85	.64	0.18	5.95	1	OS
2	29/ 7/85	.54	0.45	6.30	3	OS
2	29/ 7/85	1.36	0.07	7.85	1	OS
2	29/ 7/85	.58	0.54	5.20	1	OS
2	29/ 7/85	1.21	0.18	5.45	1	OS
2	29/ 7/85	.73	0.37	5.65	2	OS
2	29/ 7/85	.56	0.37	6.10	1	OS
2	29/ 7/85	.51	0.65	7.15	1	OS
2	29/ 7/85	1.24	0.25	5.55	2	OS
2	29/ 7/85	.66	0.34	6.30	1	OS
2	29/ 7/85	.87	0.26	5.88	7	OS
2	29/ 7/85	.60	0.52	5.05	2	OS
2	29/ 7/85	1.06	0.08	5.30	2	OS
2	29/ 7/85	.64	0.47	5.15	2	OS
2	29/ 7/85	.56	0.27	5.95	1	OS
2	29/ 7/85	.57	0.42	5.75	1	OS
2	30/ 7/85	.42	0.48	6.60	1	OS
2	30/ 7/85	.50	0.84	4.30	1	OS
2	30/ 7/85	.42	0.72	4.80	2	OS

TABLE II-1

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
2	30/ 7/85	.52	0.32	8.13	2	OS
2	30/ 7/85	.50	0.37	4.90	1	OS
2	30/ 7/85	.61	0.52	9.53	1	OS
2	30/ 7/85	.52	0.50	5.65	2	OS
2	30/ 7/85	.68	0.24	6.80	1	OS
2	30/ 7/85	.52	0.53	8.80	2	OS
2	30/ 7/85	.54	0.44	7.00	2	OS
2	30/ 7/85	.52	1.08	4.80	1	OS
2	30/ 7/85	.50	0.78	4.45	1	OS
2	30/ 7/85	.47	1.07	5.15	3	OS
2	30/ 7/85	.46	0.27	5.50	1	OS
2	30/ 7/85	.45	0.64	7.10	1	OS
2	30/ 7/85	.33	1.02	5.00	1	OS
2	30/ 7/85	.44	0.82	4.80	1	OS
2	30/ 7/85	.47	1.18	4.70	2	OS
2	30/ 7/85	.47	0.80	4.13	1	OS
2	30/ 7/85	.47	0.84	4.60	3	OS
2	30/ 7/85	.50	0.90	4.45	2	OS
2	30/ 7/85	.46	0.94	4.60	3	OS
2	30/ 7/85	.46	0.83	4.05	2	OS
2	30/ 7/85	.49	1.10	4.90	1	OS
2	30/ 7/85	.34	0.60	5.05	1	OS
2	30/ 7/85	.50	1.14	5.05	1	OS
2	30/ 7/85	.44	0.84	4.35	1	OS
2	30/ 7/85	.43	0.76	4.80	1	OS
6	29/ 8/85	.93	1.29	6.75	1	OS
6	29/ 8/85	1.11	0.67	5.70	1	OS
6	29/ 8/85	.75	0.90	6.65	3	OS
6	29/ 8/85	.81	1.48	6.70	2	OS
6	29/ 8/85	.78	0.88	6.75	1	OS
6	29/ 8/85	1.02	1.01	7.80	3	OS
6	29/ 8/85	.69	0.70	5.65	1	OS
6	29/ 8/85	1.11	0.66	5.95	3	OS
6	29/ 8/85	1.02	0.87	6.15	4	OS
6	29/ 8/85	1.26	0.18	7.50	1	OS
6	29/ 8/85	.70	0.70	6.93	2	OS
6	29/ 8/85	1.05	0.65	6.35	2	OS
6	29/ 8/85	.75	1.12	6.60	1	OS
6	29/ 8/85	.90	0.74	6.68	3	OS
6	29/ 8/85	1.14	0.70	6.00	1	OS
6	29/ 8/85	1.08	0.73	6.10	2	OS

TABLE II-1

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	29/ 8/85	1.11	0.72	6.10	2	OS
6	29/ 8/85	1.20	0.65	10.00	2	OS
6	29/ 8/85	.72	1.01	6.40	2	OS
6	29/ 8/85	.72	0.66	5.80	1	OS
6	29/ 8/85	.84	0.51	6.90	1	OS
6	29/ 8/85	1.53	0.63	9.63	3	OS
6	29/ 8/85	0.64	0.66	4.75	1	OS
6	29/ 8/85	1.14	0.62	10.00	3	OS
6	29/ 8/85	.75	0.70	6.65	2	OS
6	29/ 8/85	.78	0.84	6.25	1	OS
	AVERAGE:	0.73	0.63	6.05		
	MINIMUM:	0.18	0.06	4.05		
	MAXIMUM:	2.13	1.61	10.00		

Number of Sample Points = 133 Number of Fish = 249

TABLE II-2

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: spawning

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	19/10/85	.68	0.47	4.90		ES
6	19/10/85	1.36	1.18	5.35		ES
6	19/10/85	1.00	0.75	5.00		ES
6	19/10/85	.96	0.96	4.95		ES
6	19/10/85	.96	0.82	4.90		ES
6	19/10/85	.76	0.78	5.26		ES
6	19/10/85	.92	0.76	5.20		ES
6	19/10/85	.95	0.89	4.95		ES
6	19/10/85	.70	0.64	5.45		ES
6	19/10/85	.80	0.65	5.11		ES
6	19/10/85	.75	0.57	5.00		ES
6	19/10/85	.80	0.60	4.95		ES
6	19/10/85	1.22	0.99	4.95		ES
6	19/10/85	.66	0.61	5.30		ES
6	19/10/85	.50	0.76	5.30		ES
6	19/10/85	.92	0.74	5.00		ES
6	19/10/85	.68	0.51	5.15		ES
6	19/10/85	1.24	1.02	4.95		ES
6	19/10/85	.97	0.84	5.25		ES
6	19/10/85	.72	0.48	4.76		ES
6	19/10/85	.96	0.95	4.75		ES
6	19/10/85	.52	0.40	4.70		ES
6	20/10/85	.48	0.83	5.90		ES
6	20/10/85	.76	1.08	5.10		ES
6	20/10/85	.85	0.64	5.00		ES
6	20/10/85	.54	0.80	5.02		ES
6	20/10/85	.56	0.94	5.72		ES
6	20/10/85	.80	0.61	4.85		ES
6	20/10/85	.38	0.68	5.00		ES
6	20/10/85	.96	0.76	5.21		ES
6	20/10/85	1.18	1.02	5.35		ES
6	20/10/85	.50	0.75	5.02		ES
6	20/10/85	.32	0.79	5.10		ES
6	20/10/85	.39	0.59	4.97		ES
6	20/10/85	.33	0.96	5.07		ES
6	20/10/85	.38	0.92	4.70		ES
6	20/10/85	.61	0.91	5.20		ES
6	20/10/85	.35	0.94	4.63		ES
6	20/10/85	.42	0.84	4.78		ES
6	20/10/85	.32	0.86	5.30		ES
6	20/10/85	.65	0.68	5.25		ES

TABLE II-2

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: spawning

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	20/10/85	.59	0.84	5.35		ES
6	20/10/85	.72	0.55	4.95		ES
6	20/10/85	.58	0.75	4.89		ES
6	20/10/85	.46	0.64	5.48		ES
6	20/10/85	.49	0.66	5.41		ES
6	20/10/85	.66	1.12	5.11		ES
6	20/10/85	.62	0.84	5.50		ES
6	20/10/85	.59	0.84	5.67		ES
6	20/10/85	.60	0.96	4.85		ES
6	20/10/85	.49	0.77	4.94		ES
6	20/10/85	.54	0.84	5.55		ES
6	20/10/85	.53	0.79	5.08		ES
6	20/10/85	.98	0.86	5.25		ES
6	20/10/85	1.10	0.94	5.75		ES
6	20/10/85	.66	0.75	5.90		ES
6	20/10/85	.68	0.92	5.85		ES
6	20/10/85	.66	0.96	5.45		ES
6	20/10/85	.69	0.96	6.00		ES
6	20/10/85	.49	0.92	4.94		ES
6	20/10/85	.60	1.20	5.10		ES
6	20/10/85	.51	0.64	5.60		ES
6	20/10/85	.36	0.92	4.89		ES
6	20/10/85	.42	0.99	4.80		ES
6	20/10/85	.50	0.52	5.73		ES
6	20/10/85	.68	0.79	5.50		ES
6	20/10/85	.73	0.92	4.70		ES
6	20/10/85	.90	0.66	4.90		ES
6	20/10/85	1.00	0.82	5.30		ES
6	20/10/85	.70	1.15	5.20		ES
6	20/10/85	.92	0.72	4.60		ES
5	21/10/85	.60	1.15	6.48		ES
6	21/10/85	.67	0.94	5.68		ES
6	21/10/85	.90	0.79	6.85		ES
5	21/10/85	.54	0.96	6.48		ES
5	21/10/85	.66	1.00	6.10		ES
5	21/10/85	.58	1.15	6.50		ES
6	21/10/85	.82	0.79	6.60		ES
5	21/10/85	.74	1.05	6.05		ES
6	21/10/85	.76	0.73	5.68		ES
6	21/10/85	.94	0.57	6.60		ES
6	21/10/85	.72	1.06	6.05		ES

TABLE II-2

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: adult Activity: spawning

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	21/10/85	.72	0.90	5.63		ES
5	21/10/85	.74	1.13	6.30		ES
6	21/10/85	.61	1.13	6.21		ES
6	21/10/85	.72	0.54	6.35		ES
6	21/10/85	.75	1.05	5.80		ES
6	21/10/85	.94	0.75	6.55		ES
6	21/10/85	.77	0.58	6.60		ES
5	21/10/85	.80	1.01	6.25		ES
6	21/10/85	.75	0.56	6.75		ES
6	21/10/85	.67	0.90	6.15		ES
6	21/10/85	.84	0.84	6.30		ES
6	21/10/85	.68	0.99	5.85		ES
6	21/10/85	.81	0.87	6.45		ES
6	21/10/85	.89	0.69	6.78		ES
6	21/10/85	.58	1.13	5.95		ES
6	21/10/85	.86	0.54	6.18		ES
6	21/10/85	.60	1.04	6.38		ES
6	21/10/85	.82	0.58	6.65		ES
6	21/10/85	.80	0.79	5.75		ES
6	21/10/85	.88	0.97	6.20		ES
5	21/10/85	.60	0.88	5.85		ES
6	21/10/85	.89	0.59	6.75		ES
5	21/10/85	.68	0.83	5.85		ES
5	21/10/85	.72	0.94	6.45		ES
6	21/10/85	.60	0.59	6.05		ES
	AVERAGE:	0.71	0.82	5.53		
	MINIMUM:	0.32	0.40	4.60		
	MAXIMUM:	1.36	1.20	6.85		

Number of Sample Points = 107 Number of Fish = 0

TABLE II-3

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: eggs Activity: incubation

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Eggs	Sampling Method
5	22/10/85	.50	1.25	4.75	1	KS
5	22/10/85	.62	1.17	4.45	2	KS
5	22/10/85	.62	0.90	4.30	1	KS
5	22/10/85	.58	0.86	5.38	1	KS
5	22/10/85	.48	1.06	4.85	2	KS
5	22/10/85	.52	0.61	5.50	1	KS
5	22/10/85	.64	1.04	4.55	2	KS
5	22/10/85	.67	0.61	6.08	1	KS
5	22/10/85	.54	0.77	5.09	1	KS
5	22/10/85	.58	0.60	4.50	2	KS
5	22/10/85	.46	1.35	5.21	2	KS
5	22/10/85	.66	1.08	6.05	1	KS
5	22/10/85	.56	1.06	5.20	1	KS
5	22/10/85	.54	0.83	5.30	1	KS
5	22/10/85	.77	0.65	4.65	60	KS
5	22/10/85	.82	0.91	4.20	1	KS
5	22/10/85	.70	0.66	5.79	1	KS
5	22/10/85	.55	0.92	4.00	8	KS
5	22/10/85	.56	0.92	5.25	1	KS
5	22/10/85	.50	0.99	4.65	1	KS
5	22/10/85	.52	1.43	5.08	1	KS
4	23/10/85	.44	0.99	4.95	1	KS
	AVERAGE:	0.58	0.94	4.99		
	MINIMUM:	0.44	0.60	4.00		
	MAXIMUM:	0.82	1.43	6.08		

Number of Sample Points = 22 Number of Eggs = 93

TABLE II-4

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
4	7/ 7/85	0.18	0.96	4.11	5	OS
4	7/ 7/85	.37	0.56	5.00	1	OS
5	8/ 7/85	.79	1.57	5.65	1	OS
5	8/ 7/85	.27	0.23	5.01	1	OS
5	8/ 7/85	.61	0.77	6.65	1	OS
6	9/ 7/85	.40	0.77	5.90	1	OS
6	9/ 7/85	.55	1.01	6.50	1	OS
6	9/ 7/85	.69	1.15	5.93	1	OS
6	10/ 7/85	.69	0.94	6.41	1	OS
6	11/ 7/85	.98	0.63	6.55	1	OS
6	12/ 7/85	0.51	1.25	4.60	1	OS
6	12/ 7/85	.82	1.07	6.45	2	OS
6	12/ 7/85	.61	1.09	4.50	1	OS
6	12/ 7/85	1.01	0.75	6.54	1	OS
6	12/ 7/85	.94	1.04	8.60	1	OS
6	12/ 7/85	.55	0.41	6.69	1	OS
6	14/ 7/85	2.07	0.87	7.15	1	OS
6	14/ 7/85	2.07	0.54	6.90	1	OS
6	14/ 7/85	2.07	0.63	6.90	1	OS
4	18/ 7/85	.51	0.12	4.55	1	OS
4	18/ 7/85	.50	0.37	5.10	3	OS
4	18/ 7/85	.54	0.03	3.30	1	OS
4	18/ 7/85	.58	0.31	4.40	3	OS
4	18/ 7/85	.87	0.12	5.10	1	OS
4	24/ 7/85	.36	0.82	5.15	1	OS
4	24/ 7/85	.54	0.48	5.65	1	OS
4	24/ 7/85	.42	0.16	5.05	2	OS
4	24/ 7/85	.48	0.08	4.90	1	OS
4	24/ 7/85	.50	0.13	4.70	2	OS
4	24/ 7/85	.68	0.17	5.40	50	OS
4	24/ 7/85	.68	0.25	5.75	4	OS
4	24/ 7/85	.64	0.29	5.20	18	OS
4	24/ 7/85	.60	0.35	5.35	1	OS
4	24/ 7/85	.28	0.80	5.20	1	OS
4	24/ 7/85	.52	0.35	4.70	1	OS
4	24/ 7/85	.40	0.26	4.90	15	OS
4	24/ 7/85	.70	0.16	4.10	1	OS
4	24/ 7/85	.56	0.63	4.70	2	OS
4	24/ 7/85	.47	0.11	5.99	3	OS
4	24/ 7/85	.50	0.64	4.50	1	OS
3	25/ 7/85	.38	0.00	4.22	6	OS

TABLE II-4

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
2	25/ 7/85	.58	0.21	4.60	4	OS
3	26/ 7/85	.86	0.39	4.39	3	OS
3	26/ 7/85	.76	0.18	5.40	1	OS
3	26/ 7/85	.90	0.22	5.10	1	OS
3	26/ 7/85	.86	0.47	4.40	3	OS
3	26/ 7/85	.84	0.26	5.30	16	OS
3	26/ 7/85	.80	0.37	4.30	5	OS
3	27/ 7/85	.37	0.55	7.50	1	OS
2	28/ 7/85	.18	0.79	6.43	5	OS
2	28/ 7/85	.44	0.72	5.80	5	OS
2	28/ 7/85	.42	0.48	6.65	1	OS
2	28/ 7/85	.50	0.27	5.05	6	OS
2	28/ 7/85	.44	0.36	6.30	2	OS
2	28/ 7/85	.48	0.42	6.10	1	OS
2	28/ 7/85	.46	0.81	5.95	5	OS
2	28/ 7/85	.38	0.72	6.40	6	OS
2	28/ 7/85	.32	0.80	5.75	7	OS
2	28/ 7/85	.55	0.46	6.25	4	OS
2	28/ 7/85	.52	0.50	6.68	1	OS
2	28/ 7/85	.39	0.52	5.75	1	OS
2	28/ 7/85	.47	0.72	6.15	4	OS
2	28/ 7/85	.32	0.58	5.75	4	OS
2	28/ 7/85	.56	0.23	5.87	2	OS
2	28/ 7/85	.38	1.02	6.55	1	OS
2	28/ 7/85	.36	0.78	6.75	1	OS
2	28/ 7/85	.50	0.85	6.15	12	OS
2	28/ 7/85	.32	0.55	5.70	5	OS
2	28/ 7/85	.46	0.51	5.65	3	OS
2	29/ 7/85	.74	0.28	5.05	1	OS
2	29/ 7/85	.46	0.50	4.50	1	OS
2	29/ 7/85	.64	0.65	5.95	1	OS
2	29/ 7/85	.87	0.26	5.88	4	OS
2	29/ 7/85	.22	0.67	5.10	1	OS
2	29/ 7/85	.36	0.94	4.85	1	OS
2	29/ 7/85	.73	0.37	5.65	1	OS
2	30/ 7/85	.46	0.94	4.60	1	OS
2	30/ 7/85	.47	1.18	4.70	1	OS
2	30/ 7/85	.58	0.61	3.90	1	OS
2	30/ 7/85	.50	1.00	4.35	3	OS
2	30/ 7/85	.50	0.78	4.45	1	OS
2	30/ 7/85	.42	0.48	6.60	1	OS

TABLE II-4

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
2	30/ 7/85	.52	0.53	8.80	1	OS
2	30/ 7/85	.42	0.72	4.80	1	OS
2	30/ 7/85	.48	0.50	4.10	2	OS
2	30/ 7/85	.40	0.26	5.68	1	OS
2	30/ 7/85	.50	0.90	4.45	1	OS
2	30/ 7/85	.45	0.81	4.50	3	OS
2	30/ 7/85	.50	0.16	4.25	1	OS
2	30/ 7/85	.48	0.90	4.80	1	OS
2	30/ 7/85	.51	0.58	4.50	1	OS
2	30/ 7/85	.48	0.80	4.25	1	OS
2	30/ 7/85	.52	1.14	4.70	1	OS
2	30/ 7/85	.48	0.49	4.70	1	OS
2	30/ 7/85	.34	0.60	5.05	1	OS
2	30/ 7/85	.44	0.82	4.80	2	OS
2	30/ 7/85	.47	0.80	4.13	4	OS
2	30/ 7/85	.33	1.02	5.00	1	OS
2	30/ 7/85	.51	0.35	6.75	1	OS
2	30/ 7/85	.58	0.51	7.78	1	OS
2	30/ 7/85	.50	1.14	5.05	1	OS
2	30/ 7/85	.47	1.07	5.15	2	OS
6	4/ 8/85	.65	0.65	5.60	1	OS
6	4/ 8/85	1.06	0.52	10.00	1	OS
6	4/ 8/85	1.06	0.78	7.30	1	OS
6	4/ 8/85	.42	0.69	5.70	1	OS
5	4/ 8/85	.56	0.32	5.70	1	OS
6	4/ 8/85	.54	1.10	6.40	1	OS
6	4/ 8/85	.48	0.65	5.60	1	OS
6	29/ 8/85	1.02	1.01	7.80	1	OS
6	29/ 8/85	.69	0.70	5.65	5	OS
6	29/ 8/85	.78	0.88	6.75	1	OS
6	29/ 8/85	.67	0.63	5.70	4	OS
6	29/ 8/85	1.00	0.57	5.60	1	OS
6	29/ 8/85	.57	0.64	5.70	6	OS
6	29/ 8/85	.75	0.70	6.65	3	OS
6	29/ 8/85	.84	0.51	6.90	2	OS
6	29/ 8/85	1.14	0.70	6.00	1	OS
6	29/ 8/85	.96	0.60	6.00	1	OS
6	29/ 8/85	.75	0.90	6.65	1	OS
6	29/ 8/85	1.08	0.73	6.10	2	OS
6	29/ 8/85	.75	0.88	6.60	4	OS
6	29/ 8/85	.75	1.12	6.60	1	OS

TABLE II-4

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	29/ 8/85	1.05	0.65	6.35	1	OS
6	29/ 8/85	1.11	0.72	6.10	2	OS
6	29/ 8/85	1.11	0.66	5.95	1	OS
6	29/ 8/85	.78	0.84	6.25	5	OS
6	29/ 8/85	.69	0.73	5.75	8	OS
6	29/ 8/85	.72	0.66	5.80	2	OS
6	29/ 8/85	1.14	0.62	10.00	1	OS
6	29/ 8/85	1.20	0.65	10.00	1	OS
6	29/ 8/85	.67	0.68	5.35	3	OS
6	29/ 8/85	.76	0.88	6.55	2	OS
6	29/ 8/85	.64	0.69	6.15	1	OS
6	29/ 8/85	1.11	0.67	5.70	1	OS
6	29/ 8/85	0.64	0.66	4.75	2	OS
6	29/ 8/85	.90	0.74	6.68	1	OS
6	29/ 8/85	1.11	0.63	6.00	2	OS
6	29/ 8/85	1.26	0.18	7.50	1	OS
6	29/ 8/85	.81	1.48	6.70	1	OS
6	29/ 8/85	.99	0.54	6.30	1	OS
	AVERAGE:	0.65	0.63	5.73		
	MINIMUM:	0.18	0.00	3.30		
	MAXIMUM:	2.07	1.57	10.00		

Number of Sample Points = 141 Number of Fish = 375

TABLE II-5

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: fry Activity: rearing

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
4	17/ 7/85	.37	0.15	5.65	5	OS
4	17/ 7/85	0.22	0.45	4.92	10	OS
4	17/ 7/85	.15	0.12	5.00	1	SN
4	17/ 7/85	.16	0.63	5.70	1	SN
4	17/ 7/85	.23	0.21	5.70	6	OS
4	17/ 7/85	.29	0.34	5.39	6	SN
4	17/ 7/85	.30	0.11	4.90	1	SN
4	18/ 7/85	.44	0.12	6.85	1	OS
4	18/ 7/85	.30	0.25	5.55	12	OS
4	18/ 7/85	.22	0.32	5.98	30	OS
4	18/ 7/85	.20	0.50	10.00	6	OS
4	18/ 7/85	.44	0.42	5.30	1	OS
4	18/ 7/85	.50	0.12	6.50	1	OS
4	18/ 7/85	.34	0.25	6.93	1	OS
4	18/ 7/85	.22	0.32	5.13	1	OS
4	18/ 7/85	.45	0.15	6.55	1	OS
4	18/ 7/85	.32	0.15	4.55	7	OS
4	18/ 7/85	.21	0.45	4.65	1	EF
4	18/ 7/85	.17	0.59	5.75	7	OS
4	18/ 7/85	.28	0.20	4.89	1	EF
4	18/ 7/85	.14	0.44	5.25	1	EF
4	18/ 7/85	.22	0.32	5.50	1	OS
4	18/ 7/85	.20	0.55	5.25	1	EF
4	18/ 7/85	.19	0.57	6.15	2	SN
4	18/ 7/85	.28	0.23	4.90	3	OS
4	18/ 7/85	.38	0.09	6.45	6	OS
4	18/ 7/85	.47	0.13	5.90	25	OS
4	18/ 7/85	.33	0.15	6.80	6	SN
4	18/ 7/85	.44	0.05	3.11	1	OS
4	18/ 7/85	.26	0.15	5.50	1	OS
4	18/ 7/85	.44	0.09	4.90	1	OS
4	24/ 7/85	.37	0.48	5.08	5	OS
4	24/ 7/85	.40	0.86	5.25	2	OS
4	24/ 7/85	.22	0.00	1.00	1	OS
4	24/ 7/85	.38	0.76	5.18	2	OS
4	24/ 7/85	.30	0.40	5.63	3	OS
4	24/ 7/85	.58	0.26	5.30	100	OS
4	24/ 7/85	.26	0.24	5.05	2	OS
4	24/ 7/85	.34	0.48	4.95	7	OS
4	24/ 7/85	.21	0.15	5.25	1	OS
4	24/ 7/85	0.32	0.11	4.00	30	OS

TABLE II-5

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: fry Activity: rearing

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
4	24/ 7/85	.50	0.54	4.70	1	OS
4	24/ 7/85	.16	0.28	4.70	1	OS
4	24/ 7/85	0.54	0.20	4.30	4	OS
4	24/ 7/85	0.36	0.14	5.10	1	OS
4	24/ 7/85	0.38	0.15	4.75	50	OS
4	24/ 7/85	.45	0.70	4.80	1	OS
4	24/ 7/85	.30	0.21	5.50	2	OS
4	24/ 7/85	0.38	0.16	5.00	1	OS
4	24/ 7/85	.18	0.14	5.35	5	OS
4	24/ 7/85	.28	0.29	4.63	100	OS
4	24/ 7/85	.31	0.13	5.35	2	OS
4	24/ 7/85	.31	0.17	5.05	6	OS
4	24/ 7/85	.28	0.27	5.05	1	OS
4	24/ 7/85	.33	0.11	5.70	12	OS
4	24/ 7/85	.30	0.26	5.15	50	OS
4	24/ 7/85	.33	0.16	4.75	24	OS
4	24/ 7/85	.30	0.07	5.50	30	OS
4	24/ 7/85	.52	0.20	4.80	2	OS
4	24/ 7/85	.16	0.21	5.30	1	OS
4	24/ 7/85	.22	0.08	1.50	1	OS
4	24/ 7/85	.36	0.30	4.50	25	OS
4	24/ 7/85	.45	0.22	9.00	1	OS
4	24/ 7/85	.35	0.05	5.05	1	OS
4	24/ 7/85	.16	0.37	5.75	1	OS
4	24/ 7/85	.40	0.11	4.10	30	OS
3	25/ 7/85	.38	0.00	4.22	4	OS
3	27/ 7/85	.32	0.43	5.83	1	OS
3	27/ 7/85	.18	0.34	5.60	4	OS
3	27/ 7/85	.38	0.11	9.50	6	OS
3	27/ 7/85	.34	0.06	6.71	1	OS
3	27/ 7/85	.29	0.35	5.05	1	OS
3	27/ 7/85	.38	0.30	6.35	1	OS
3	27/ 7/85	.18	0.78	5.55	1	OS
3	27/ 7/85	.22	0.62	5.90	1	OS
3	27/ 7/85	.30	0.42	5.53	1	OS
3	27/ 7/85	.44	0.18	10.00	2	OS
3	27/ 7/85	.44	0.31	5.90	3	OS
3	27/ 7/85	.34	0.30	9.63	1	OS
3	27/ 7/85	.40	0.24	4.80	1	OS
3	27/ 7/85	.20	0.32	5.00	10	OS
3	27/ 7/85	.42	0.29	9.17	1	OS

TABLE II-5

FISH HABITAT OBSERVATIONS

Species: mountain whitefish

Stage: fry Activity: rearing

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
3	27/ 7/85	.34	0.24	4.11	2	OS
3	27/ 7/85	.36	0.14	9.98	2	OS
3	27/ 7/85	.40	0.17	5.55	1	OS
3	27/ 7/85	.18	0.09	6.11	1	OS
3	27/ 7/85	.40	0.35	5.83	1	OS
2	28/ 7/85	.30	0.34	5.15	1	OS
2	28/ 7/85	.25	0.51	4.46	1	OS
5	4/ 8/85	.50	0.78	4.90	1	OS
5	4/ 8/85	.56	0.58	6.23	1	OS
5	4/ 8/85	.53	0.74	4.90	1	OS
5	4/ 8/85	.58	0.69	5.18	1	OS
5	4/ 8/85	.55	0.69	5.15	1	OS
5	4/ 8/85	.60	0.64	5.30	1	OS
6	4/ 8/85	.31	0.58	6.05	1	OS
5	4/ 8/85	.50	0.69	5.35	1	OS
5	4/ 8/85	.34	0.71	5.55	1	OS
5	4/ 8/85	.60	0.55	5.60	1	OS
5	4/ 8/85	.47	0.63	5.40	1	OS
5	4/ 8/85	.61	0.40	5.70	1	OS
5	4/ 8/85	.45	0.72	5.40	1	OS
5	4/ 8/85	.48	0.72	5.00	1	OS
5	4/ 8/85	.56	0.60	5.10	1	OS
6	29/ 8/85	.57	0.72	5.80	1	OS
6	29/ 8/85	.99	0.54	6.30	1	OS
6	29/ 8/85	.33	0.82	5.95	1	OS
AVERAGE:		0.35	0.34	5.54		
MINIMUM:		0.14	0.00	1.00		
MAXIMUM:		0.99	0.86	10.00		

Number of Sample Points = 107 Number of Fish = 720

TABLE II-6

FISH HABITAT OBSERVATIONS

Species: rainbow trout

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	9/ 7/85	.75	0.63	6.60	1	OS
6	12/ 7/85	1.65	0.93	9.10	1	OS
5	14/ 7/85	.94	0.61	9.80	1	OS
5	14/ 7/85	.37	0.06	10.00	1	OS
5	15/ 7/85	1.40	1.30	6.31	1	OS
5	4/ 8/85	1.50	0.41	7.80	1	OS
5	4/ 8/85	1.50	0.41	7.80	1	OS
6	5/ 8/85	1.18	0.37	9.80	1	OS
6	5/ 8/85	1.82	0.83	6.50	1	OS
AVERAGE:		1.23	0.62	8.19		
MINIMUM:		0.37	0.06	6.31		
MAXIMUM:		1.82	1.30	10.00		

Number of Sample Points = 9 Number of Fish = 9

TABLE II-7

FISH HABITAT OBSERVATIONS

Species: rainbow trout

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	9/ 7/85	.82	0.99	6.76	2	OS
6	9/ 7/85	.95	0.78	5.90	2	OS
6	9/ 7/85	.61	0.84	5.90	1	OS
6	10/ 7/85	1.17	0.37	6.58	1	OS
6	10/ 7/85	1.32	1.13	6.55	1	OS
6	11/ 7/85	.79	0.32	6.45	1	OS
6	11/ 7/85	1.34	0.85	7.15	2	OS
6	11/ 7/85	1.04	0.80	6.70	1	OS
6	12/ 7/85	.70	1.15	5.55	1	OS
6	12/ 7/85	.55	0.90	6.65	1	OS
6	12/ 7/85	.96	0.64	6.53	1	OS
6	12/ 7/85	1.83	1.02	8.00	5	OS
6	12/ 7/85	.61	0.69	6.10	1	OS
6	12/ 7/85	.82	1.05	6.40	1	OS
6	12/ 7/85	1.13	0.92	6.20	1	OS
6	12/ 7/85	.61	0.98	4.90	1	OS
6	12/ 7/85	.91	0.48	8.90	1	OS
6	14/ 7/85	.91	1.37	7.88	1	OS
6	14/ 7/85	1.07	0.81	8.27	1	OS
6	14/ 7/85	1.16	0.80	6.40	1	OS
6	14/ 7/85	1.65	0.81	8.69	1	OS
6	14/ 7/85	.88	0.75	6.65	1	OS
6	14/ 7/85	.91	0.64	5.90	1	OS
6	14/ 7/85	1.22	1.01	7.40	1	OS
6	14/ 7/85	1.43	0.75	8.51	1	OS
6	14/ 7/85	1.43	0.79	9.69	1	OS
5	15/ 7/85	1.40	0.20	1.00	1	OS
5	15/ 7/85	1.52	1.17	5.67	1	OS
5	15/ 7/85	.85	0.59	6.40	2	OS
5	15/ 7/85	1.34	1.00	5.40	2	OS
5	15/ 7/85	1.16	0.35	8.90	1	OS
5	15/ 7/85	1.19	0.81	6.35	1	OS
5	15/ 7/85	1.31	0.99	6.60	1	OS
5	15/ 7/85	1.34	1.10	6.38	1	OS
5	4/ 8/85	1.15	0.72	5.01	1	OS
5	4/ 8/85	.86	0.73	5.30	1	OS
5	4/ 8/85	.87	0.44	6.25	1	OS
6	5/ 8/85	1.42	0.22	7.90	1	OS
6	5/ 8/85	.75	0.26	7.35	1	OS
6	5/ 8/85	1.10	0.29	8.60	1	OS
6	5/ 8/85	1.15	0.34	8.15	1	OS

TABLE II-7

FISH HABITAT OBSERVATIONS

Species: rainbow trout

Stage: Juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	5/ 8/85	.95	0.75	5.85	1	OS
6	5/ 8/85	.68	0.72	7.95	1	OS
6	5/ 8/85	.80	0.34	7.05	1	OS
6	5/ 8/85	.64	0.17	8.08	1	OS
6	5/ 8/85	.76	0.83	7.05	1	OS
6	5/ 8/85	.74	0.62	7.45	1	OS
6	5/ 8/85	.86	0.37	7.60	1	OS
6	5/ 8/85	.63	0.50	6.05	1	OS
6	5/ 8/85	.62	0.42	5.95	1	OS
6	5/ 8/85	.80	0.37	8.10	1	OS
6	5/ 8/85	1.00	0.52	8.85	1	OS
6	5/ 8/85	1.25	0.81	7.30	1	OS
6	5/ 8/85	.74	0.32	10.00	1	OS
6	5/ 8/85	.75	0.49	8.11	1	OS
6	5/ 8/85	.82	0.23	9.83	1	OS
6	5/ 8/85	1.36	0.69	7.00	1	OS
6	5/ 8/85	1.00	0.52	8.85	1	OS
6	5/ 8/85	1.20	0.65	9.15	1	OS
6	5/ 8/85	.72	0.19	6.50	1	OS
6	6/ 8/85	.99	1.03	8.10	1	OS
6	6/ 8/85	2.02	0.38	7.10	1	OS
6	6/ 8/85	1.46	0.56	8.60	1	OS
6	6/ 8/85	.90	0.85	7.55	1	OS
6	6/ 8/85	1.14	0.37	7.69	1	OS
6	6/ 8/85	.82	1.15	7.05	1	OS
6	6/ 8/85	1.10	0.65	8.00	1	OS
6	6/ 8/85	.96	1.06	6.80	1	OS
6	6/ 8/85	.92	0.13	7.05	1	OS
6	6/ 8/85	.87	0.40	7.65	1	OS
6	6/ 8/85	.69	0.76	7.15	1	OS
6	6/ 8/85	.63	0.57	6.00	1	OS
6	6/ 8/85	2.14	0.23	6.00	1	OS
6	6/ 8/85	.76	0.35	9.23	1	OS
6	6/ 8/85	.48	0.38	8.78	1	OS
6	6/ 8/85	1.18	0.61	6.75	1	OS
6	6/ 8/85	1.00	0.36	8.78	1	OS
6	6/ 8/85	.64	0.69	7.50	1	OS
6	28/ 8/85	.60	0.90	7.00	1	OS
6	28/ 8/85	.90	0.54	5.50	1	OS
6	28/ 8/85	1.02	0.90	6.58	1	OS
6	28/ 8/85	.90	0.22	7.40	1	OS

TABLE II-7

FISH HABITAT OBSERVATIONS

Species: rainbow trout

Stage: juvenile Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
6	28/ 8/85	.81	0.63	5.90	1	OS
6	28/ 8/85	.72	0.50	6.20	1	OS
6	28/ 8/85	.78	1.48	7.80	1	OS
6	28/ 8/85	.84	0.58	6.20	1	OS
6	28/ 8/85	.87	0.00	7.20	1	OS
6	28/ 8/85	.93	0.94	6.60	1	OS
6	28/ 8/85	.63	1.35	6.80	1	OS
6	28/ 8/85	1.11	0.52	7.28	1	OS
6	28/ 8/85	1.38	0.25	8.10	1	OS
6	28/ 8/85	1.16	0.45	7.70	1	OS
6	28/ 8/85	1.59	0.43	9.60	1	OS
6	28/ 8/85	1.02	0.98	6.30	1	OS
6	28/ 8/85	1.08	0.87	7.75	1	OS
6	28/ 8/85	.87	0.51	9.80	1	OS
6	28/ 8/85	1.05	0.98	6.20	1	OS
6	28/ 8/85	1.02	1.23	7.30	1	OS
6	28/ 8/85	.65	0.65	6.25	1	OS
6	28/ 8/85	1.56	0.40	9.30	1	OS
6	28/ 8/85	1.14	0.37	7.05	1	OS
6	29/ 8/85	.99	0.19	8.25	1	OS
	AVERAGE:	1.01	0.65	7.18		
	MINIMUM:	0.48	0.00	1.00		
	MAXIMUM:	2.14	1.48	10.00		

Number of Sample Points = 102 Number of Fish = 111

TABLE II-8

FISH HABITAT OBSERVATIONS

Species: northern pike

Stage: adult Activity: feeding

Study Segment	Date (D/M/Y)	Depth (m)	Mean Column Velocity (m/s)	Substrate Index	Number of Fish	Sampling Method
4	7/ 7/85	.46	0.00	1.50	1	OS
5	15/ 7/85	1.13	0.02	1.50	1	OS
	AVERAGE:	0.80	0.01	1.50		
	MINIMUM:	0.46	0.00	1.50		
	MAXIMUM:	1.13	0.02	1.50		

Number of Sample Points = 2 Number of Fish = 2